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THE SPECIES COMPOSITION, SEASONAL SUCCESSION, REPRODUCTION AND DISTRIBUTION OF MARINE ALGAE FROM SCITUATE TO WOODS HOLE, MASSACHUSETTS

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by

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ABSTRACT

The species composition, seasonal succession, reproduction and distribution of the marine algae at seven stations from Scituate to Woods Hole, Massachusetts, including the Cape Cod Canal, were described. Particular attention was paid to the transitional nature of the Cape Cod Canal, which connects the warm waters of Buzzards Bay and the cold waters of Cape Cod Bay. Bimonthly collections were made from January to December, 1969. A total of 106 species was recorded. Each species was categorized as a northern, southern, or cosmopolitan form, according to its major center of distribution. The majority of species was cosmopolitan, but distinct northern and southern components were also found.

Conspicuous differences in species numbers were evident at each station. Scituate and Woods Hole had the highest numbers, while intermediate values were recorded in the Canal. Most of the species at Scituate and in the Canal were perennials; annuals were most abundant at Wings Neck and Woods Hole. The Rhodophyceae accounted for most of the spring and summer annuals, while the browns were the major contributors of winter annuals. Spring and early summer annuals appeared several weeks sooner at Wings Neck and Woods Hole than at Scituate. Some species appeared as spring annuals south of the Cape, but as summer annuals at Scituate. The reproductive periodicity of most species was recorded at each station. Some species reproduced throughout the year, while others were

restricted to either warm or cold seasons.

The vertical distributions of the species at each station were categorized. Most species at Scituate were found in the intertidal and/or subtidal zone(s), while those at all other stations were collected primarily in the subtidal zone. Numerous factors are responsible for the vertical displacement of species recorded. An interpretation of the distributional patterns is given.

INTRODUCTION

Cape Cod is a major geographic boundary on the northeast coast of North America, delineating a northern and southern flora (Setchell, 1922; Stephenson and Stephenson, 1949; Chapman, 1964; Humm, 1969). Its importance as a phytogeographic boundary was first recognized by Harvey (1852-1858) and later by Farlow (1870, 1882). Additional information regarding the uniqueness of the Cape Cod flora was contributed by Collins (1900) and Davis (1913a,b). Taylor (1937, 1957) compiled all of the known floristic information on the northeast coast of North America (including Cape Cod).

Although the marine flora of Cape Cod has received considerable attention since the time of Harvey, no one has ever conducted simultaneous year-round studies of the algae on both sides of the Cape in order to determine seasonal and spatial differences of the floras. In addition, nothing is known about the seasonal changes that take place in the Canal, which joins Cape Cod Bay and Buzzards Bay. Conover (1958) and Sears (1971) have recently conducted seasonal studies of the algae in southern Cape Cod. Conover described the productivity and seasonal composition of the algae in relation to a variety of environmental parameters in the Great Pond Estuary of Falmouth. Sears described the subtidal benthic algae of several sites in southern Cape Cod, but he gave no consideration to the Canal.

The purpose of this investigation was to study the marine algae at seven locations from Scituate to Woods Hole, Massachusetts, including the Cape Cod Canal, relative to their species composition, seasonal succession, vertical distribution, and reproductive periodicity. In addition, an attempt was made to correlate seasonal temperature differences between the north and south sides of the Cape, and to evaluate the Cape Cod Canal as a transitional zone between northern and southern floras.

METHODS AND MATERIALS

Monthly collections of all the conspicuous algae at 7 stations were made from January to December, 1969. Severe winter conditions (heavy ice and surf) existed from December to March and they restricted some collections. Specimens were collected from the intertidal and subtidal zones to a depth of about 60 feet. Subtidal collections were made by SCUBA. Diving in the Canal was done at predicted slack water (Anon. 1969 b). The specimens were brought to the University of New Hampshire for processing, identification, and study of reproductive structures. The following references were consulted for identification of species and determination of presently known geographical distributions along the Atlantic Coast of North America (Adey, 1964, 1965, 1966; Bell and MacFarlane 1933 a,b; Blomquist and Humm, 1946; Cardinal, 1964, 1965, 1966, 1967 a,b,c, 1968; Collins, 1909; Edelstein, et al, 1970; Edelstein and McLachlan 1966, 1967 a,b, 1968 a,b, 1969; Edelstein, et al, 1967, 1969; Fritsch, 1935, 1945; Hoyt, 1920; Lamb and Zimmermann, 1964; Lee, 1968, 1969; Lewis, 1914; MacFarlane and Bell, 1933; MacFarlane and Milligan, 1965; Mathieson and Fuller, 1969; Mathieson, Dawes and Humm, 1969; Rhodes, 1970; Stone, et al, 1970; Taylor, 1937, 1957, 1960; Wilce, 1959; Williams, 1948, 1949; Wulf et al, 1968; Zaneveld and Barnes, 1965; Zaneveld, 1965, 1966 a,b). The nomenclature of Parke and Dixon (1964, 1968) was applied in most cases.

Surface water temperature and salinity information was recorded at each station. Temperature was determined with a mercury thermometer, while salinity was measured with a set of hydrometers (F. M. Mfg., Co.). In addition, hourly and daily surface water temperature data were obtained for each end of the Canal from thermographs monitored by the Fisheries Division of the State of Massachusetts. Additional (daily) temperature and salinity information was supplied by the Woods Hole Oceanographic Institute, Falmouth, Massachusetts (communication with Dean Bumpus and Joseph Chase).

DESCRIPTION OF AREA AND ENVIRONMENTAL FACTORS

The seven stations involved in the study extended along the southeast coast of Massachusetts from Scituate to Woods Hole, including the Cape Cod Canal. One station was located north of the east end of the Canal, four were in the Canal proper, and two were located south of the west end of the Canal (Fig. 1). The Canal (Fig. 2) cuts across the Cape from the town of Buzzards Bay (approx. 41°44'N. latitude and 70°37'W. longitude) to Sandwich (approx. 41°46'N. latitude and 70°30'W. longitude).

Several differences are obvious between the two sides of the Cape. To the north, the substrate consists of granite outcrops, boulders and cobbles, while to the south the substrate is largely sand and mud with fewer boulders. The Cape is also the dividing line between the Labrador Current to the north and the Gulf Stream to the south. Thus, a marked difference in water temperatures occurs during the summer. The yearly temperature range south of the Cape was approximately 22°C, while that to the north was about 17°C (Fig. 5). Salinity ranges were comparable on both sides (Fig. 4). The tidal amplitude is much greater on the north than the south side. Thus, a 3 foot tidal amplitude exists in Buzzards Bay, while it is approximately 10 feet at Scituate (Anon. 1969 a). The waters of Cape Cod Bay are deeper (over 100 feet) than those in Buzzards Bay (less than 100 feet).

The Canal is a transition zone between Cape Cod Bay and Buzzards Bay. It has a limited amount of solid substrate, no wave action, and a reduced intertidal zone. The seasonal temperature ranges are intermediate between the north and south sides of the Cape, but daily fluctuations in the Canal during the summer were greater than on either side of the Cape (Fig. 5 & 6). A diurnal temperature range of 11°C occurred on July 23rd (Fig. 6). All of the Canal stations experienced the same general patterns, except that the daily temperatures were somewhat lower at the east end during the summer (Fig. 5). Figure 7 summarizes the hourly variation of temperatures in the Canal on two dates. The July date representing a time of maximum diurnal variation and the January one of minimal variation. Seasonal and spatial variations of salinity were minimal in the Canal (Fig. 4). The tidal amplitude in the Canal ranges from 4 feet in the west end to 10 feet in the east end (Anon. 1969 a). The substrate ranges from granitic boulders to sand and silt. A description of each station is summarized below.

Scituate (station 1) is located about 30 miles north of the east end of the Canal at approximately 42°12'N. latitude and 70°43'W. longitude (Fig. 1). It is a semi-exposed site, consisting of massive granite outcroppings. There are several tide pools; a well developed intertidal zone is present. The substrate in the subtidal zone consists of large outcroppings, boulders, cobbles and sand. The surface water temperatures ranged from approximately 2-16°C (Fig. 5). The

highest temperatures occurred in August, while the lowest occurred in March. The daily temperature range was about 2°C during the summer and 3°C during the winter (Fig. 6). The average monthly summer temperatures at Scituate were the lowest of all the stations. Salinity values remained relatively constant throughout the year ranging from a low of 30.6 °/oo in the summer to a high of 32.5 °/oo during the winter (Fig. 4).

The land-cut of the Canal is in an east-west direction. It is 7 miles in length with an additional 7 mile approach (Fig. 2). The general contour of the Canal is indicated in Figure 3. The granite boulders lining the upper banks are commonly called the "rip-rap"; they extend to about 3 feet below M.L.W. A shelf composed of smaller rocks and Mytilus edulis extends laterally from the bottom of the "rip-rap" to about 50 feet into the Canal. The shelf slopes to a depth of about 4 feet below M.L.W. The channel occurs below the shelf and it is also lined with granite boulders. The bottom of the Canal is composed of sand and it is located about 36 feet below M.L.W. The overall width of the Canal is 700'; the channel is 540' wide. There is a difference of about 2 hours between the tides at the two ends (Anon. 1969 a). The current reaches a peak of about 6 knots, 3 hours after slack water. Slack water occurs uniformly throughout the Canal and it does not coincide with either high or low water (Anon. 1969 b). There is a general decrease in stable substrate towards the east end.

The Canal is maintained by the Army Corps of Engineers. A private access road along the banks was used to reach the stations. Telephone poles are located at 100 foot intervals along the Canal and are numbered beginning at the east end. Stations 2-5 are located in the Canal and correspond to poles 10, 45, 245 and 385, respectively.

Station 2 is located at the east end of the Canal at the Scusset Breakwater (Fig. 2). Collections were restricted to the intertidal zone because of the lack of subtidal substrate. An extensive intertidal zone is present. The water temperatures ranged from 2°C to 19°C (Fig. 5). The tidal amplitude is 10 feet (Anon. 1969 a).

Station 3 is located at the power plant (Fig. 2). The "rip-rap" extends to about 2 meters below M.L.W. with the shelf extending out 30-40 feet and to a depth of 15 feet. During operation, the power plant discharges water of over 23.9°C. Substrate is limited and a small intertidal zone is present. The tidal amplitude is similar to that of station 2.

Station 4 is approximately 2½ miles east of the west end of the Canal proper (Fig. 2). The collecting site was on the south bank of the Canal. The substrate in the subtidal zone was diverse. The tidal amplitude is about 6 feet (Anon. 1969 a). A limited intertidal zone is exposed during low tide.

Station 5 is located at the Engineer's station at the west end of the Canal. Collections were made in the vicinity of the pier. The "rip-rap" extends to about 12 feet below M.L.W. The shelf is about 75 feet wide and slopes to about

20 feet below M.L.W. The tidal amplitude is about 4 feet (Anon. 1969 a).

Station 6 (Wings Neck) is located at approximately 41°31'N. latitude and 70°40'W. longitude in the town of Bourne, Massachusetts (Fig. 1). It is a semi-exposed area subject to southwest winds during the summer. A limited intertidal zone is present; it is composed of small cobbles and a few large boulders. A few shallow tide pools are evident. The tidal amplitude is about 4 feet (Anon. 1969 a). The range of water temperatures (.2°C to 22.1°C) was the same as at Woods Hole (Fig. 5). The mean monthly winter temperature (2.2°C) was lowest in January. At that time the temperature was lower than at Scituate, the northernmost station. The area is subject to severe ice scouring during the winter. The salinity remained relatively constant throughout the year with a range of about .9 °/oo (Fig. 4).

Station 7 (Woods Hole) is located at approximately 41°31'N. latitude and 70°40'W. longitude in the town of Falmouth, Massachusetts (Fig. 1). Collections were made at the jetty behind the U. S. Fisheries Building. The bottom is approximately 20 feet below M.L.W. at the deepest point, and the bottom substrate is composed of sand and silt. Some small rocks were present at one side of the jetty. The tidal amplitude at Woods Hole is about 2 feet (Anon. 1969 a). The temperature ranged from a low of 0.2°C in January to 22.5°C in August (Fig. 5). Daily temperature ranges were small during the year (Fig. 6). The salinity remained relatively constant throughout the year with a range of only .8 °/oo (Fig. 4).

GENERAL SPECIES COMPOSITION

A total of 106 taxa was collected at the seven stations, including 52 Rhodophyta, 35 Phaeophyta, and 19 Chlorophyta (Tables I-VII). A detailed description of each species is given in the Appendix. A listing of the known geographical distribution of each taxon along the Atlantic Coast of North American is also designated numerically as follows:

#1 Northern Massachusetts to Newfoundland and north
#2 Northern Massachusetts to Nova Scotia
#3 Southern New England-Long Island Sound to Gaspé and Labrador
#4 Southern New England-Long Island to Newfoundland and north
#5 New Jersey-Maryland to Newfoundland and north
#6 New Jersey-Maryland to Gaspé and Labrador
#7 New Jersey-Maryland to Cape Cod
#8 North Carolina to Newfoundland and north
#9 North Carolina to Gaspé
#10 South Carolina to Newfoundland and north
#11 South Carolina to northern Massachusetts
#12 Tropics to southern New England-Cape Cod
#13 Tropics to northern Massachusetts
#14 Tropics to Newfoundland and north
#15 Southern New England-Long Island South to northern New England-Nova Scotia
#16 Tropics to northern New England-Nova Scotia

The species can be grouped into three components (i.e. northern, southern and cosmopolitan) according to their major center of distribution. The northern species are found most commonly north of the Cape, and they include groups 1,2,3,4 and 15. The southern species are more common south of the Cape; they include groups 7,11 and 12. Cosmopolitan species are found on each side of the Cape, and they include groups 5,6,8,9,10 and 16.

Figure 8 summarizes the number of species in each group

at stations 1-7. Most of the species were cosmopolitan. The northern component declined towards the south, while the southern component increased towards the south, reaching a maximum at Wings Neck and Woods Hole. Cosmopolitan species included Chaetomorpha melagonium, Rhizoclonium tortuosum, Ulva lactuca, Ascophyllum nodosum, Petalonia fascia, Ahnfeltia plicata, and Ceramium rubrum, while conspicuous northern components included Codiolum petrocelidis, Monostroma spp., Chorda filum, Fucus spiralis, Laminaria digitata, Choreocolax polysiphoniae, and Porphyra umbilicalis. Representative species more common to the south of the Cape included Codium fragile ssp. tomentosoides, Sargassum filipendula, Agardhiella tenera, Champia parvula and Hypnea musiformis.

Scituate had a species composition typical of northern New England, while Wings Neck and Woods Hole were more typical of warmer water locations. Thus, Laminaria spp., Gigartina stellata, Ralfsia fungiformis, Chaetomorpha atrovirens, Urospora collabens, and Fucus vesiculosus were common at the former stations, while Sargassum filipendula, Agardhiella tenera, Callithamnion baileyi and Codium fragile ssp. tomentosoides were common at the latter stations. The Canal stations, 3-5, included representatives from both sides of the Cape (e.g. Laminaria saccharina, Chondrus crispus, Rhodymenia palmata, Agardhiella tenera, Codium fragile ssp. tomentosoides, and Sargassum filipendula.

TOTAL NUMBER OF SPECIES PER STATION

Figure 9 summarizes the total number of species at each station. Scituate and Woods Hole showed the greatest diversity, while stations 2-6 showed lower numbers. No subtidal collections were made at station 2. It is of interest to note that the relative percentages of red, brown, and green algae is about the same at each station.

Figures 10 and 11 summarize the monthly number of species per station. A distinction is made between reds, browns and greens. There was an increase in numbers during the spring and summer, except at stations 2, 3 and 4. The time of occurrence of peak numbers varied at different stations. Changes were usually most obvious from January to June, except at stations 3 and 4. A gradual decline in numbers was observed from June to December at each station.

The majority of species at each station belonged to the Rhodophyceae and Phaeophyceae; the lowest numbers were members of the Chlorophyceae. The red algae showed a greater increase in numbers during the spring and early summer than did either the browns or greens. Seasonal changes in numbers were greatest at Scituate, Wings Neck and Woods Hole.

LONGEVITY OF SPECIES

Of the 106 taxa collected, 49 were annuals, and 57 were perennials (see Appendix). Perennials accounted for the largest number of species at each station, except at Wings Neck and Woods Hole (Fig. 12). Tables VIII-X summarize the monthly total of annuals and perennials at each station. The ratio of percent annuals/perennials at each station was as follows: station 1 - 42/58; station 2 - 44/56; station 3 - 40/60; station 4 - 42/58; station 5 - 43/57; station 6 - 54/46; station 7 - 54/46. Some annuals were found only during certain times of the year (e.g. Chorda spp., Leathesia difformis, Monostroma spp., Urospora spp., Agardhiella tenera, Bangia fuscopurpurea and Champia parvula), while others were found throughout the year (e.g. Petalonia fascia, Scytosiphon lomentarius, Asperococcus echinatus, Enteromorpha intestinalis, Ulva lactuca and Dumontia incrassata).

Tables XI-XII summarize the dominant annuals and perennials on each side of the Cape. The term "dominant" is used to characterize those species that were obvious and easily collected. The perennials can be divided into three groups as follows: 1) species either restricted or more abundant north of the Cape; 2) species either restricted or more abundant south of the Cape; 3) species common on both sides of the Cape. The first groups included Choreocolax polysiphoniae, Gigartina stellata, Petrocelis middendorfii, Plumaria elegans, Fucus distichus ssp. distichus and Chaetomorpha atrovirens.

The second group included Callithamnion baileyi, Sargassum filipendula, and Codium fragile ssp. tomentosoides. The last group included Ceramium rubrum, Chondrus crispus, Corallina officinalis, Sphacelaria cirrosa and Chaetomorpha linum.

The annuals can also be divided into three groups as follows: 1) winter; 2) spring; 3) summer. The first group included Bangia fuscopurpurea, Dumontia incrassata, Chorda tomentosa, Petalonia fascia and Codiolum petrocelidis. The second group included Desmarestia viridis, Desmotrichum balticum, Punctaria plantaginea, Enteromorpha linza, Monostroma greville, and Monostroma pulchrum. The third group included Dasya pedicellata, Champia parvula, Chondria sedifolia, Grinnellia americana, Hypnea musciformis and Seirospora griffithsiana. In addition, some species that were spring annuals at Wings Neck and Woods Hole, occurred as summer annuals at Scituate (e.g. Agardhiella tenera, Leathesia difformis, Callithamnion roseum, Ceramium strictum, Gloiosiphonia capillaris and Lomentaria baileyana). The winter annuals had the fewest representatives.

Figure 13 summarizes the monthly total of annual species at three representative stations - a northern, southern and a Canal station. The largest numbers of annuals occurred during the spring and summer months, except at station 4. A decrease occurred during the colder months.

SEASONAL AND GEOGRAPHICAL SUCCESSION

Tables I-VII summarize the seasonal succession of species at each station. The annuals can be divided into three groups as follows: 1) species occurring earlier south than north of the Cape; 2) species disappearing earlier south than north of the Cape; 3) species found throughout the year and showing no seasonal succession on either side of the Cape. (Table XIII).

The annual kelp, Chorda filum, appeared simultaneously in the Canal and on the south shore of the Cape, but it was not found at Scituate until several weeks later. However, other annuals (e.g. Agardhiella tenera, Lomentaria baileyana, and Ceramium strictum) appeared successively at Woods Hole, the Canal stations and finally at Scituate. A few annuals (e.g. Dasya pedicellata and Grinnellia americana) were collected at all stations except Scituate. The spring and summer annuals (e.g. Ceramium strictum, Agardhiella tenera, Lomentaria baileyana, Chorda filum and Leathesia difformis) showed a conspicuous spatial succession while the winter annuals (e.g. Bangia fuscopurpurea, Chorda tomentosa and Petalonia fascia) appeared simultaneously at all stations.

VERTICAL DISTRIBUTION

Figure 14 summarizes the vertical distribution of all species at stations 1-7. The distribution of each taxon was recorded as follows: 1) species restricted to the intertidal zone; 2) species restricted to the subtidal zone; 3) species found in both the intertidal and subtidal zones. Most of the species at Scituate were collected from the intertidal and subtidal zones, including tide pools. Species that were common to both zones included Chondrus crispus, Chorda spp., Ectocarpus siliculosus, Petalonia fascia, Ceramium rubrum, Corallina officinalis, Dumontia incrassata and Chaetomorpha linum. Few species (e.g. Chaetomorpha atrovirens, Cladophora flexuosa, Polyides rotundus, Asperococcus echinatus, and Laminaria spp.) were restricted to the subtidal zone or intertidal zone (e.g. Codiolum spp., Enteromorpha intestinalis, Rhizoclonium tortuosum, Elothrix flacca, Choreocolax polysiphonia and Fucus spiralis). Subtidal substrate was lacking at station 2 and the lowest number of species was found here.

The Canal stations (3-5) had the highest subtidal component. Species in the Canal were also found in the intertidal zone at other stations. The most common subtidal species in the Canal included Laminaria spp., Chondrus crispus, Agardhiella tenera, Chorda spp., Chordaria flagelliformis, Ulva lactuca, Petalonia fascia and Scytosiphon lomentarius. Species restricted to the intertidal zone included Urospora

penicilliformis, Ascophyllum nodosum, Fucus spiralis and Choreocolax polysiphoniae; those common to both zones included Ectocarpus siliculosus, Fucus vesiculosus and Sphacelaria cirrosa.

The majority of species collected at Wings Neck and Woods Hole was found in the subtidal zone and the intertidal-subtidal zones. Few species were restricted to the intertidal zone. Species restricted to the subtidal zone included Agardhiella tenera, Sargassum filipendula, Callithamnion roseum, Dasya pedicellata, Seirospora griffithsiana, Leathesia difformis, Chordaria flagelliformis and Cladophora spp. Species found in both zones included Chondrus crispus, Melobesia lejolisii, Ectocarpus siliculosus, F. vesiculosus V. sphaerocarpus and Chaetomorpha linum, while those restricted to the intertidal zone included Bangia fuscopurpurea, Porphyra umbilicalis, Fucus spiralis and Ulothrix flacca.

REPRODUCTION

Tables I-VII summarize the reproductive periodicity of all species collected. Information on the crustose corallines and the majority of the greens is limited because of difficulty in determining reproductive structures. Those species common to both sides of the Cape showed differences in reproductive periods. The annuals can be divided into three groups according to their reproductive patterns as follows: 1) species reproducing earlier south than north of the Cape; 2) species terminating reproduction earlier south than north of the Cape; 3) species reproducing throughout the year north of the Cape, but with limited reproductive periods to the south. Examples of each group are as follows: 1) Agardhiella tenera, Chorda filum, Leathesia difformis, Ceramium strictum, Chordaria flagelliformis and Asperococcus echinatus; 2) Bangia fuscopurpurea, Dumontia incrassata, Porphyra umbilicalis, Leathesia difformis, Petalonia fascia and Monostroma grevillei; 3) Porphyra umbilicalis, Petalonia fascia and Scytosiphon lomentarius. Table XIV summarizes all of the species found in each group.

The perennials can also be divided into three groups according to their reproductive patterns as follows: 1) species primarily reproducing during the colder months; 2) species primarily reproducing during the warmer months; 3) species reproducing throughout the year. Examples of each of the groups are as follows: 1) Chondrus crispus, Petrocelis

middendorfii, Laminaria spp. and Polyides rotundus; 2) Callithamnion baileyi and Cystoclonium purpureum var cirrhosum; 3) Ascophyllum nodosum, Fucus spp., Pilayella littoralis, Sphacelaria cirrosa and Ahnfeltia plicata. The generalized groupings of species according to reproductive periods were not always consistent at all stations. For examples, Pilayella littoralis and Chondrus crispus had an extended reproductive period north of the Cape, but exhibited limited periods of reproduction to the south.

Tables I-VII also summarize the reproductive structures on each species. The most common reproductive organs on the brown algae were plurilocular sporangia (e.g. Ectocarpus siliculosus, Petalonia fascia and Scytosiphon lomentarius). Propagules were abundant on Sphacelaria cirrosa. Tetraspores and carpospores were common reproductive organs on the red algae. Spermatia were only found on a few species (e.g. Polysiphonia lanosa and Callithamnion roseum). Carpotetraspores were found on Phyllophora brodiaei. Gametes were found on some of the green algae (e.g. Monostroma spp.), while zoospores were found on others (e.g. Ulothrix flacca and Urospora collabens).

EFFECTS OF A POWER PLANT

The most obvious effect of the exhaust effluent was in the immediate area of the discharge chute where there was a reduction in number of species, particularly during July and August. At a distance of 35 or more feet from the chute, the flora (both the composition and species numbers) were essentially like that at the other Canal stations (Fig. 10). The rocks at the opening of the chute were covered by a few heat tolerant (?) species including Ulva lactuca, Codium fragile ssp. tomentosoides and Chordaria flagelliformis. The species at the chute opening showed the same seasonal succession as those at the warm water stations of Wings Neck and Woods Hole, and their seasonal development was not comparable to other Canal stations. For example, Leathesia difformis and Chorda filum appeared at the chute opening earlier than at the other Canal stations (compare Tables III to IV), while Grinnellia americana and Agardhiella tenera remained viable for longer periods than at any other location.

An extensive fish and seaweed kill was observed on two occasions. It is known that antifouling chemicals (Sodium hyperchlorite) are used in the cooling system and the deaths are presumed to be the result of the chemicals.

DISCUSSION

As suggested earlier, several authors (Harvey, 1852-1858; Farlow, 1870, 1882; Collins, 1900, 1909; Davis, 1913 a, b; Setchell, 1922; Chapman, 1964; Humm, 1969) have emphasized that Cape Cod is a major phytogeographic boundary for the algae with distinct floras north and south of the Cape. Farlow (1882) and Davis (1913 a,b) also stated that species from one side of the Cape were only found on the opposite side under favorable temperature conditions. Davis further suggested that spores were transported around the Cape by currents and they survived adverse periods in a resting state. Setchell (1922) recognized a cosmopolitan group of species common to both sides of the Cape in contrast to more northern and southern elements. The completion of the Canal in 1914 provided a direct route for spores to pass from one side of the Cape to the other.

Setchell (1917) divided the oceans into temperature zones of 5°C intervals or isotherms according to maximum summer surface water temperatures. Cape Cod was recognized as a dividing line between the 15°C and 20°C isotherms. In addition, Setchell (1920) proposed a delineation of species according to temperatures as follows: 1) species found in waters of 20°C or higher; 2) species found in waters of less than 20°C. Hutchins (1947) later confirmed that 5°C isotherms either favored or inhibited growth and repopulation in the marine environment. Other workers including Williams (1948),

Parr (1933), Wells and Gray (1960), and Humm (1969) have reported a similar relationship between temperature and species composition.

Several factors are responsible for the marked difference in summer temperatures between the north and south side of Cape Cod. A southern extension of the Labrador Current carries cold water as far south as the Cape where it remains throughout the year. The deep waters of Cape Cod Bay react slowly to the sun's insolation. Thus, the temperatures of open coastal waters north of the Cape seldom exceed 16°C, while those to the south often exceed 20°C. Davis (1913 a,b) described Cape Cod Bay as a "holding pocket" of cold water. He further described the islands of Martha's Vineyard and Nantucket as barriers protecting Buzzards Bay from the intrusion of cold waters off Gay Head.

The high surface water temperatures in Buzzards Bay result from a northern extension of the Gulf Stream into the shallow confines of Buzzards Bay. During the winter, cold air lowers the temperature on both sides of the Cape and the sharp temperature differential disappears. Winter temperatures in Buzzards Bay, however, may be somewhat lower than Cape Cod Bay because of the shallowness of the former location.

Among others, Lewis (1964) has indicated the importance of salinity in determining species composition and zonation patterns. However, salinity was not considered a major factor in my study areas, because of the small range (30.6 °/oo - 32.5 °/oo) recorded.

Each of the 106 species collected was placed into one of three categories (northern, southern and cosmopolitan) according to its major center of distribution. Many of the northern and southern species extended to the Cape only during the winter and summer, respectively. Thus, the transitional nature of the Cape is illustrated in Figure 8, particularly at the Canal stations that are dominated by cosmopolitan species. It should, however, be noted that the majority of the species at each station was cosmopolitan.

Although temperature was the most important factor in determining the geographical components at each station, the total number of species per station was determined by other physical factors, such as tidal amplitude, wave action and substrate. The highest number of species was found at Scituate; the most exposed site having ample substrate. The lack of wave action, lower tidal amplitude and reduced substrate in the Canal were responsible for low numbers of species. Woods Hole had the second highest number, even though tidal amplitude, wave action and substrate were reduced south of the Cape. The high numbers at Woods Hole were probably a result of the high numbers of annuals that come and go from the area over a year. The abrasive action of sand and competition for space at Wings Neck resulted in low species numbers.

The general increase in numbers of species observed in

the spring resulted from an influx of warm water annuals. The spring increase in annuals was most obvious south of the Cape. At most stations, peak numbers of species were reached during the early summer and a general decline occurred thereafter. The persistence of winter annuals also contributed to high numbers in the spring. Annuals were more important than perennials in determination of seasonal fluctuations in species numbers. Conspicuous variations of annuals would be expected to characterize a transitional site such as Cape Cod. Red algae were the major contributors of annuals during the warmer months, while greens and browns were most conspicuous during the colder months. Similar results were recorded by Sears (1971).

Davis (1913 a,b) indicated that the wide temperature ranges in the Cape Cod region resulted in two distinct types of seasonal annuals: 1) winter-spring; 2) mid-summer or early autumn. My observations indicate that there are three distinct types of seasonal annuals - winter, spring, and summer. His second category is probably analagous to those forms designated as summer annuals. In addition to the three major groups of annuals discussed above, some annuals showed no seasonal specificity and reproduced throughout the year. Sears (1971) referred to such annuals as "aseasonal".

Warm water perennials were most luxuriant during the summer south of the Cape. Setchell (1920), Williams (1948) and Chapman (1964) state that species may enter a resting

stage during extreme temperature conditions. Sears (1971) reported germlings of several red algae overwintering in deep waters off Martha's Vineyard. Cold water perennials might be expected to enter a comparable stage during the warmer months.

The ratios of annuals to perennials varied at different stations. North of Cape Cod perennials predominated in numbers of species, while to the south there were more annuals. Intermediate ratios were found in the Canal. The high summer temperatures south of the Cape allowed warm water annuals to move north to Buzzards Bay. The cooler winter temperatures in the same location also allowed cold water annuals to become established.

Geographical differences of seasonal succession were evident. For example, warm water annuals occurred earlier south of the Cape than north, while many cold water annuals remained longer north of the Cape than south of it. The early appearance of warm water annuals south of the Cape resulted from higher spring temperatures in Buzzards Bay. Likewise, some cold water annuals remained longer north of the Cape, because of the lower spring temperatures in Cape Cod Bay. Spring temperatures south of the Cape eventually become too high for the cold water annuals. Setchell (1920) considered warm water species (particularly annuals) as being stenothermal, while cold water species were eurythermal. In addition, Humm (1969) indicated that warm water species were slow in adapting to cold waters north of Cape Cod. Williams (1949) stated that areas with wide temperature ranges supported a wider

range of annuals. Thus, warm water annuals should be more dominant south of the Cape, than to the north. It is apparent that the differences in seasonal successions recorded at the stations were primarily dependent on temperature differentials.

Several factors including tidal amplitude, wave action and substrate influenced the vertical distribution of the species (Stephenson and Stephenson, 1949; Chapman, 1964). Most algae at Scituate were collected from the intertidal and subtidal zones, while in the Canal and south the majority was restricted to the subtidal zone. The former location (Scituate) is characterized by greater tidal amplitude and wave action, both of which are necessary for the development of an extensive intertidal flora - assuming substrate is not limiting. Davis (1913 a,b) recorded somewhat similar results for southern Cape Cod. The vertical position of species varied from station to station. Species found in the intertidal and subtidal zones at Scituate were often restricted to the subtidal zone in the Canal or south of the Cape.

As suggested by Setchell (1920) and Hutchins (1947), the reproductive periodicities of the species involved in this study were controlled primarily by temperature. Differences in reproductive periodicities were evident at different stations. For example, warm water annuals initiated reproduction earlier south than north of the Cape, while cold water annuals reproduced longer north than south. The reproduction of some annuals was restricted to the south, but not to the

north. The reproduction of perennials showed patterns similar to the annuals; again indicating the importance of temperature differences.

A few summary comments should be made on the role of the power plant on the vegetation at station 3. As suggested earlier, the most obvious effect of the thermal enrichment was the decrease in species numbers in the immediate area of the discharge chute. The coincidence of high summer temperature and the warm water discharge were most harmful during July and August, as evidenced by the extreme paucity of the flora at that time. The discharge of chemicals from the cooling system may also limit the growth of algae at the mouth of the chute, particularly during the summer. An extensive fish kill was observed on two occassions, presumably because of an over application of Sodium hyperchlorite used in the plant. The influence of the warm water discharge was limited to a latteral distance of about 30-35 feet from the chute. A fast current is responsible for the dispersal of much of the heated water in the Canal. If the swift currents were not present, major alterations in the Canal's biota would result.

The species composition, seasonal succession, vertical distribution, and reproductive periodicity of the algae at seven stations from Scituate to Woods Hole, Massachusetts was studied. Thus, the importance of Cape Cod as a major transitional zone has been demonstrated.

SUMMARY

1. The species composition, seasonal succession, vertical distribution and reproductive periodicity of the algae at seven stations from Scituate to Woods Hole, Massachusetts demonstrated the importance of Cape Cod as a major transitional zone.
2. Cape Cod is a distinct barrier between the cold waters of Cape Cod Bay and the warm waters of Buzzards Bay. The Cape Cod Canal provides a direct route between the north and south sides of the Cape, its northeastern end being at Cape Cod Bay and the southwestern end at Buzzards Bay.
3. The greatest temperature differential between the north and south sides of the Cape exists during the summer.
4. One hundred six species of algae were recorded. Each species was characterized as northern, southern, or cosmopolitan according to its major center of distribution. The northern species decreased from east to west through the Canal, while the southern groups decreased in numbers from west to east. Most species were cosmopolitan forms that were common on both sides of the Cape.
5. A summarization of the species numbers found at each station showed the highest numbers were recorded at Scituate and Woods Hole, while the Canal stations had the lowest numbers. In general, species numbers were highest during the spring due to an influx of spring annuals,

and a long residence of winter annuals. A decline in species numbers occurred from June to December. The red algae accounted for the greater portion of the numbers during the spring, while the brown algae showed their greatest increase in the winter.

6. The majority of species at Scituate and in the Canal was perennials, while at Wings Neck and Woods Hole they were primarily annuals.
7. The annuals were divided into three groups according to their seasonal succession. Some species occurred earlier south than north of the Cape, while others remained longer north than south of the Cape. A third group was found throughout the year and showed no specific seasonal succession.
8. The vertical distribution of each species was recorded at all stations. The majority of species was collected from the intertidal or subtidal zones at Scituate, while most species in the Canal and south of the Cape were restricted to the subtidal zone. An interpretation of the distribution patterns is given.
9. The reproductive periodicities of most species were recorded. Temperature was the primary factor in controlling seasonal reproduction. Differences in reproductive patterns were evident at each station. Some species reproduced primarily during the colder months, other primarily during the warmer months, while some reproduced continuously.

10. The gross effects of thermal enrichment from a power plant were evaluated. The most obvious effect was a decrease in numbers of species (especially during July and August) in the immediate area of the discharge chute. The discharge of chemicals from the cooling system probably contributed to reducing species numbers and an extensive fish kill. The swift current in the Canal disperses the heated water rapidly, thus reducing the area influenced to about 30-35 feet from the chute.

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Figure 1. Map of Cape Cod, Massachusetts

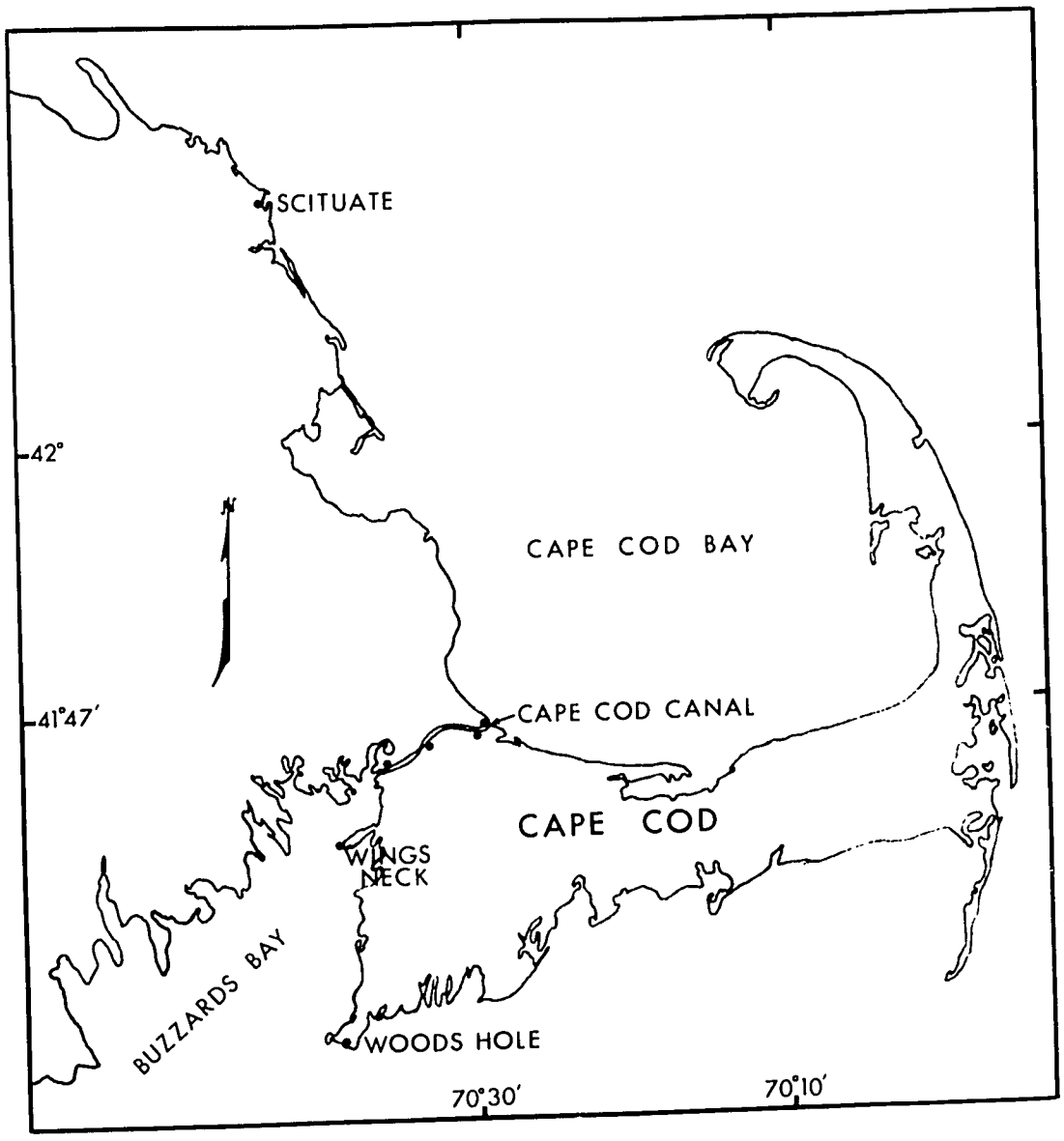

SCITUATE
42°
CAPE COD BAY
41°47′
CAPE COD CANAL
CAPE COD
WINGS NECK
BUZZARDS BAY
WOODS HOLE
70°30′
70°10′

Figure 2. Map showing stations 2-5 in the Cape Cod Canal

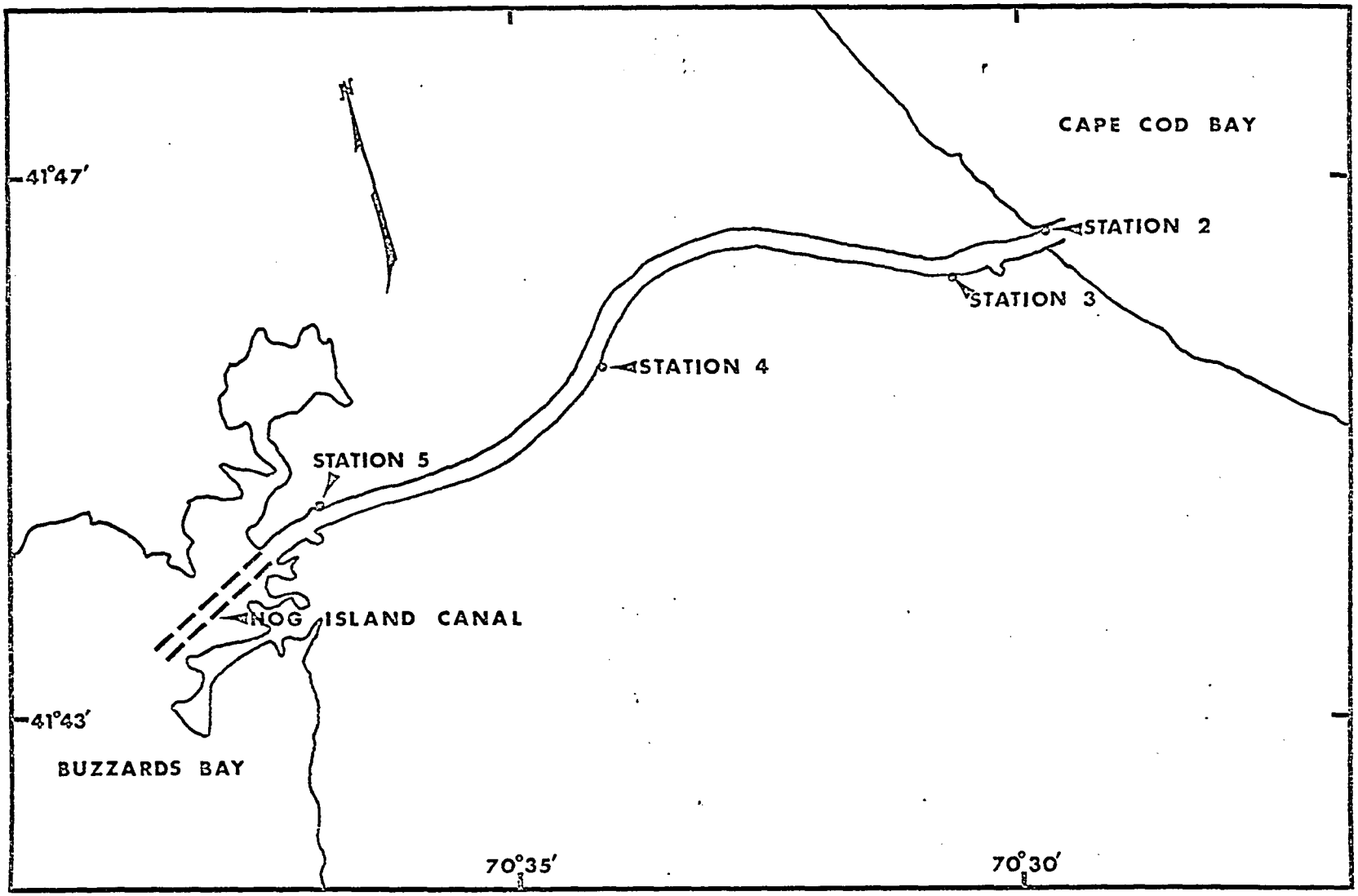

CAPE COD BAY
41°47'
STATION 2
STATION 3
STATION 4
STATION 5
HOG ISLAND CANAL
41°43'
BUZZARDS BAY
70°35'
70°30'

Figure 3. Contour of the Cape Cod Canal

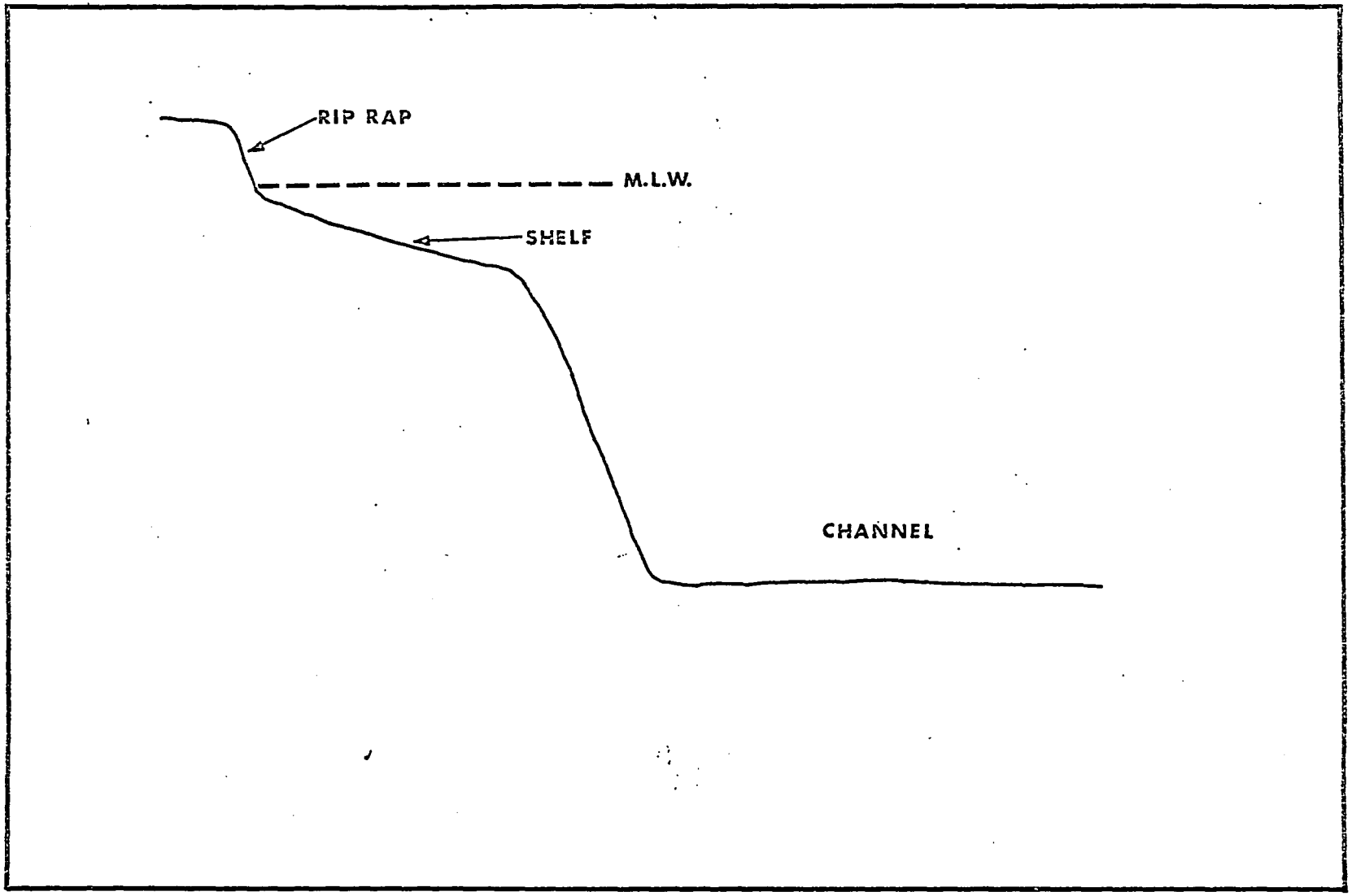

RIP RAP
M.L.W.
SHELF
CHANNEL

Figure 4. Mean monthly variation of surface water salinity at stations 1,3,5 and 7 during 1969

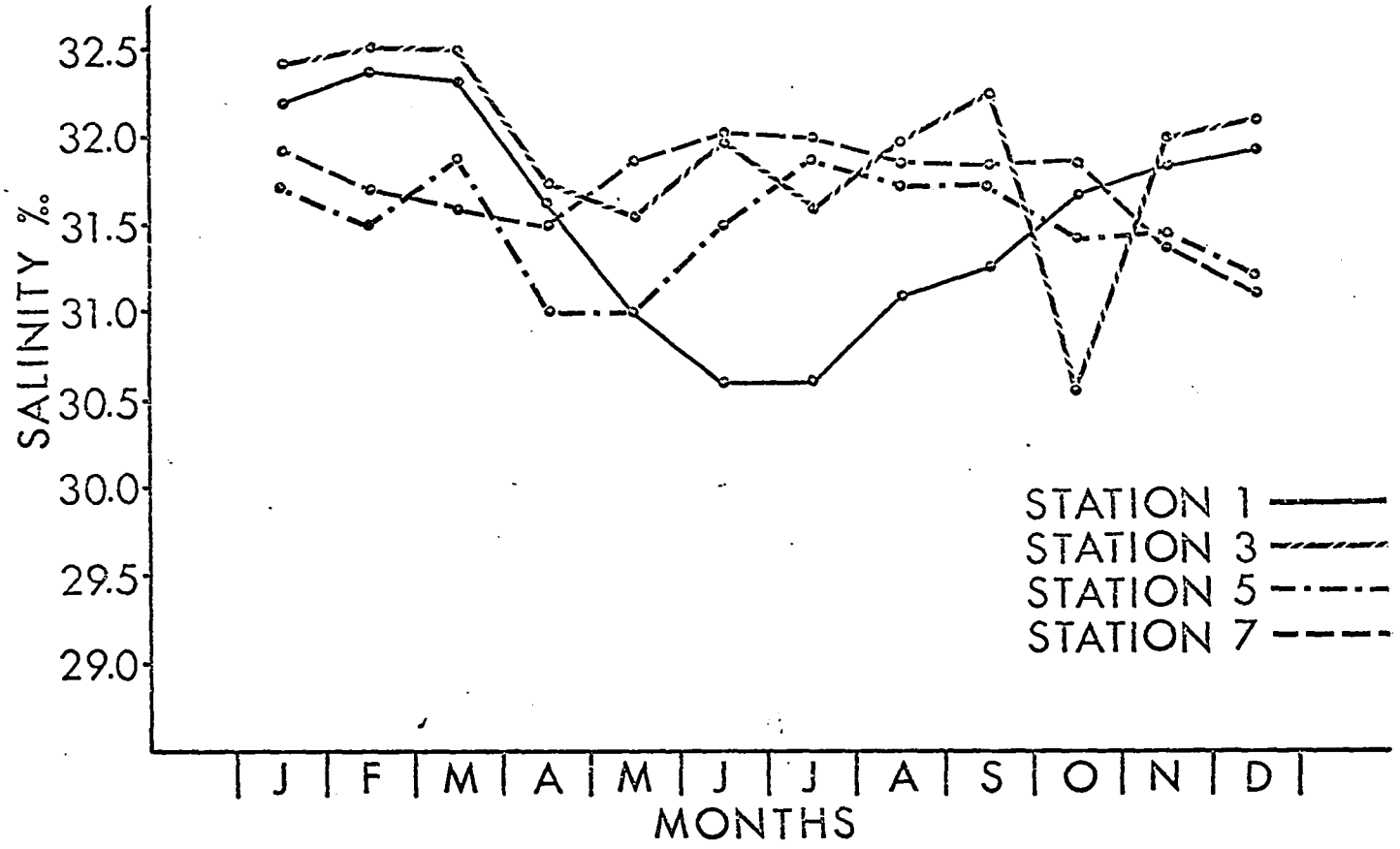

SALINITY ‰
32.5
32.0
31.5
31.0
30.5
30.0
29.5
29.0
J
F
M
A
M
J
J
A
S
O
N
D
MONTHS
STATION 1
STATION 3
STATION 5
STATION 7

Figure 5. Mean monthly variation of surface water temperatures at stations 1,3,5 and 7 during 1969

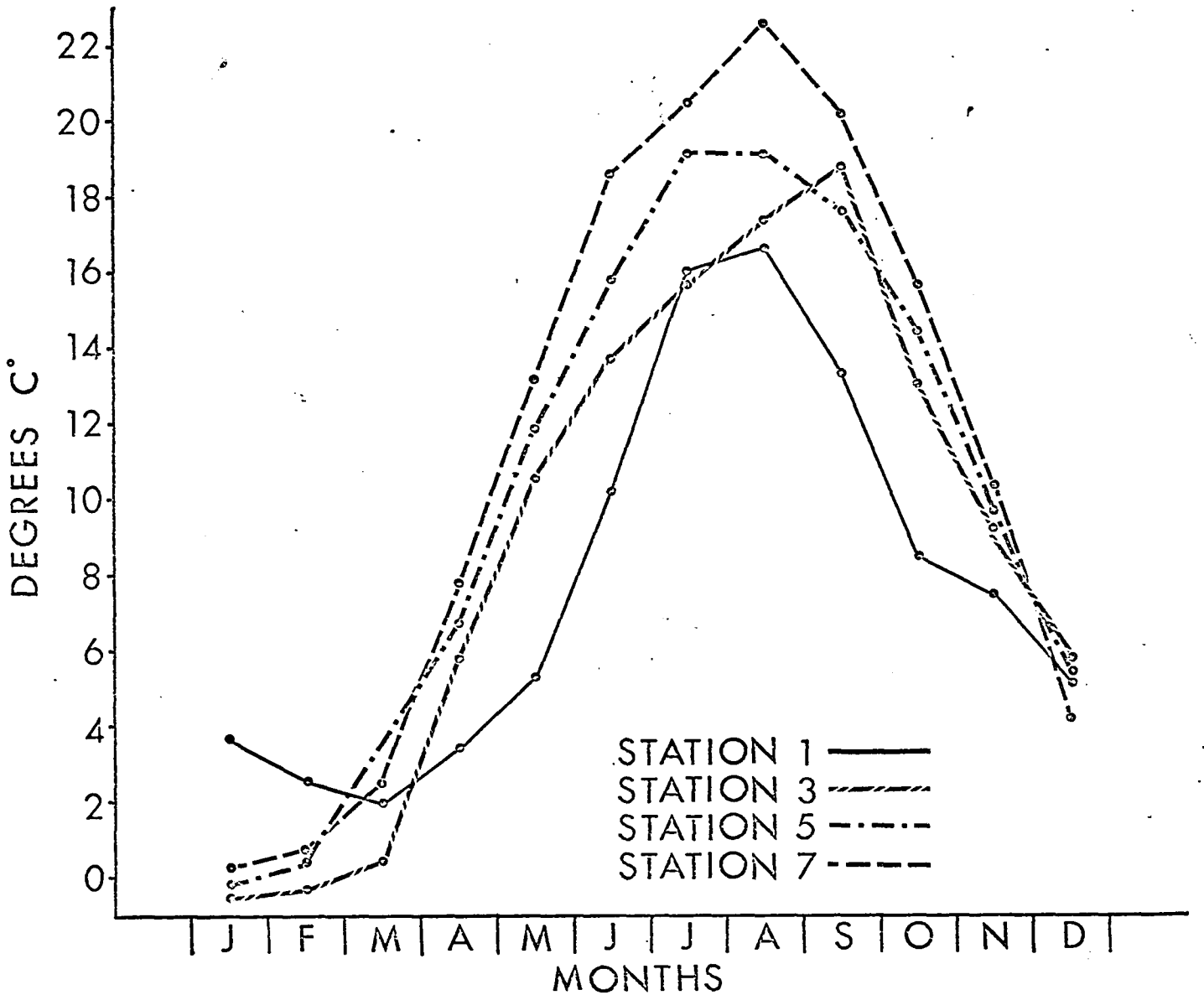

DEGREES C°
22
20
18
16
14
12
10
8
6
4
2
0
J
F
M
A
M
J
J
A
S
O
N
D
MONTHS
STATION 1
STATION 3
STATION 5
STATION 7

Figure 6. Mean daily variation of surface water temperatures at stations 1,3,5 and 7 during January and July, 1969

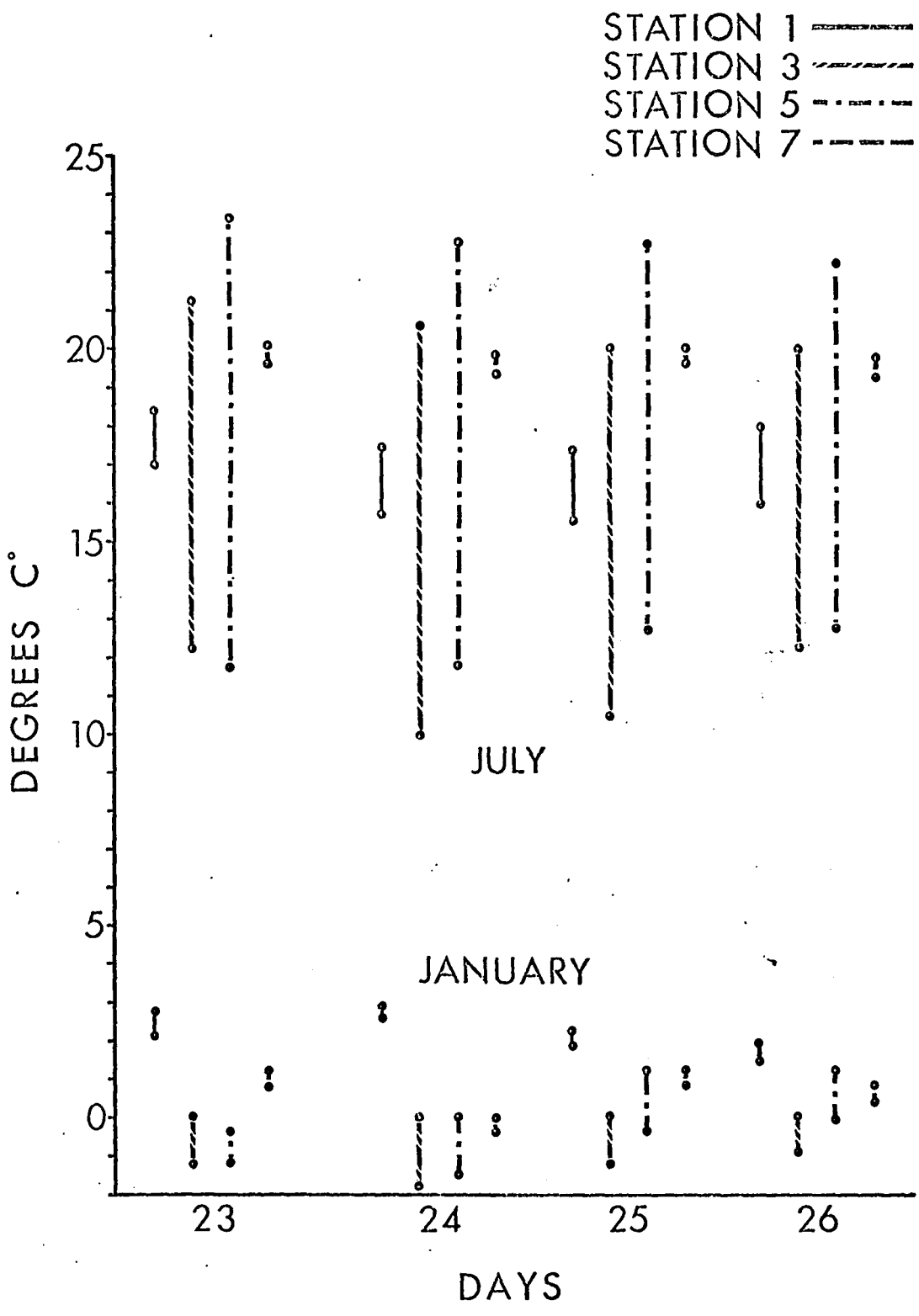

STATION 1
STATION 3
STATION 5
STATION 7
25
20
15
10
5
0
DEGREES C°
JULY
JANUARY
23
24
25
26
DAYS

Figure 7. Hourly variation of surface water temperatures in the Cape Cod Canal during January and July, 1969

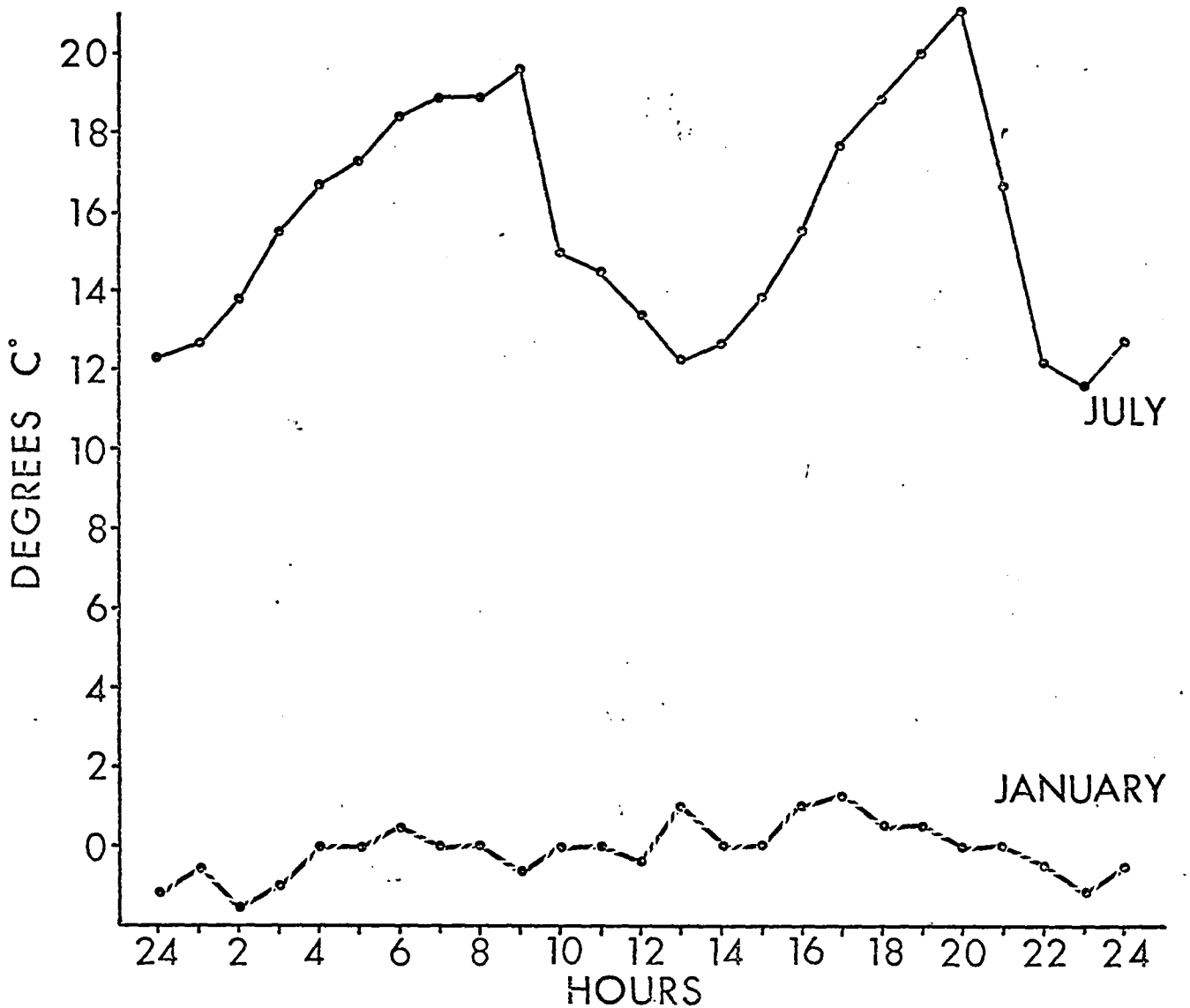

DEGREES C°
20
18
16
14
12
10
8
6
4
2
0
JULY
JANUARY
24 2 4 6 8 10 12 14 16 18 20 22 24
HOURS

Figure 8. Number of northern, southern and cosmopolitan species at each station

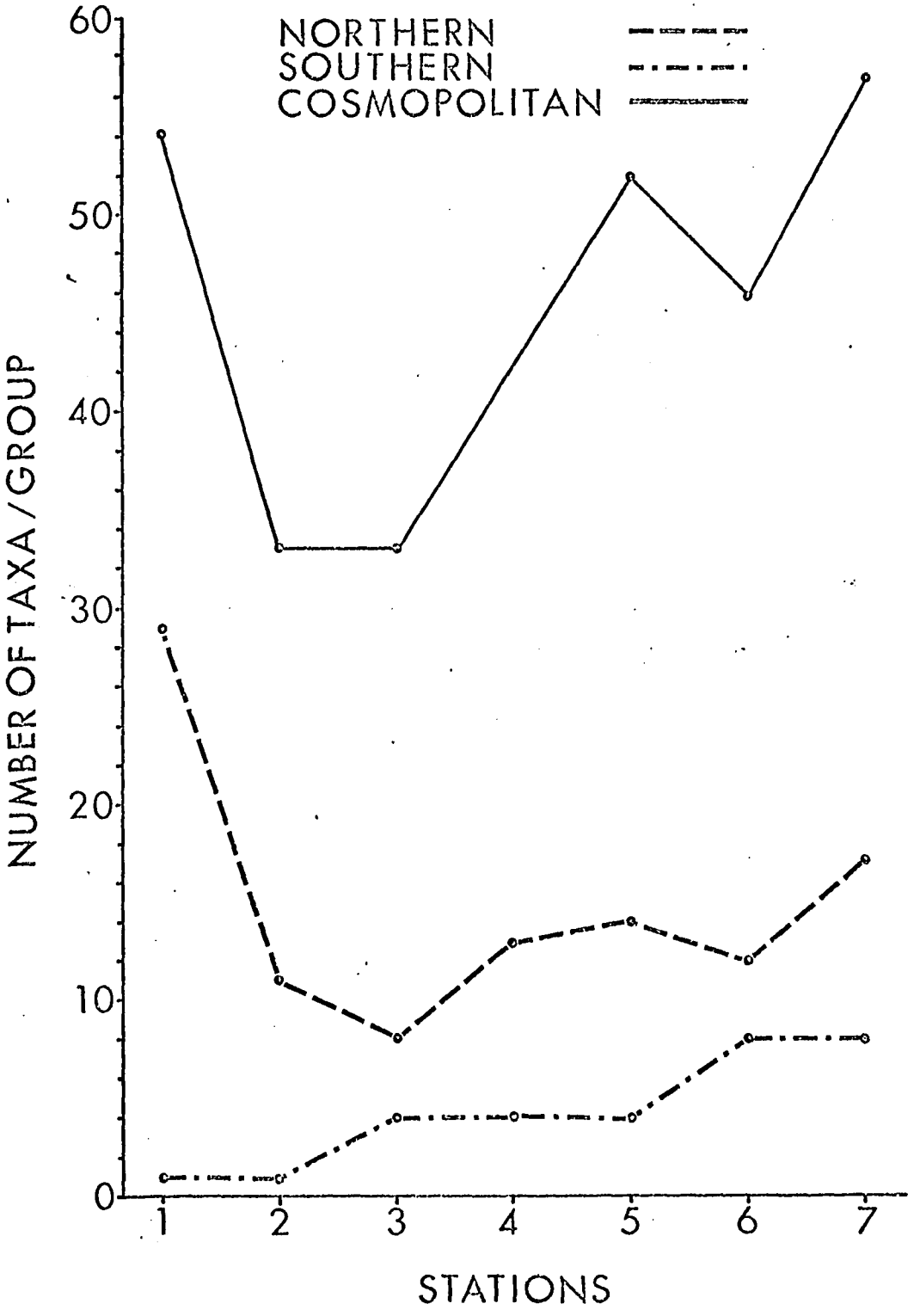

NORTHERN
SOUTHERN
COSMOPOLITAN
NUMBER OF TAXA / GROUP
60
50
40
30
20
10
0
1
2
3
4
5
6
7
STATIONS

Figure 9. Number of species at each station

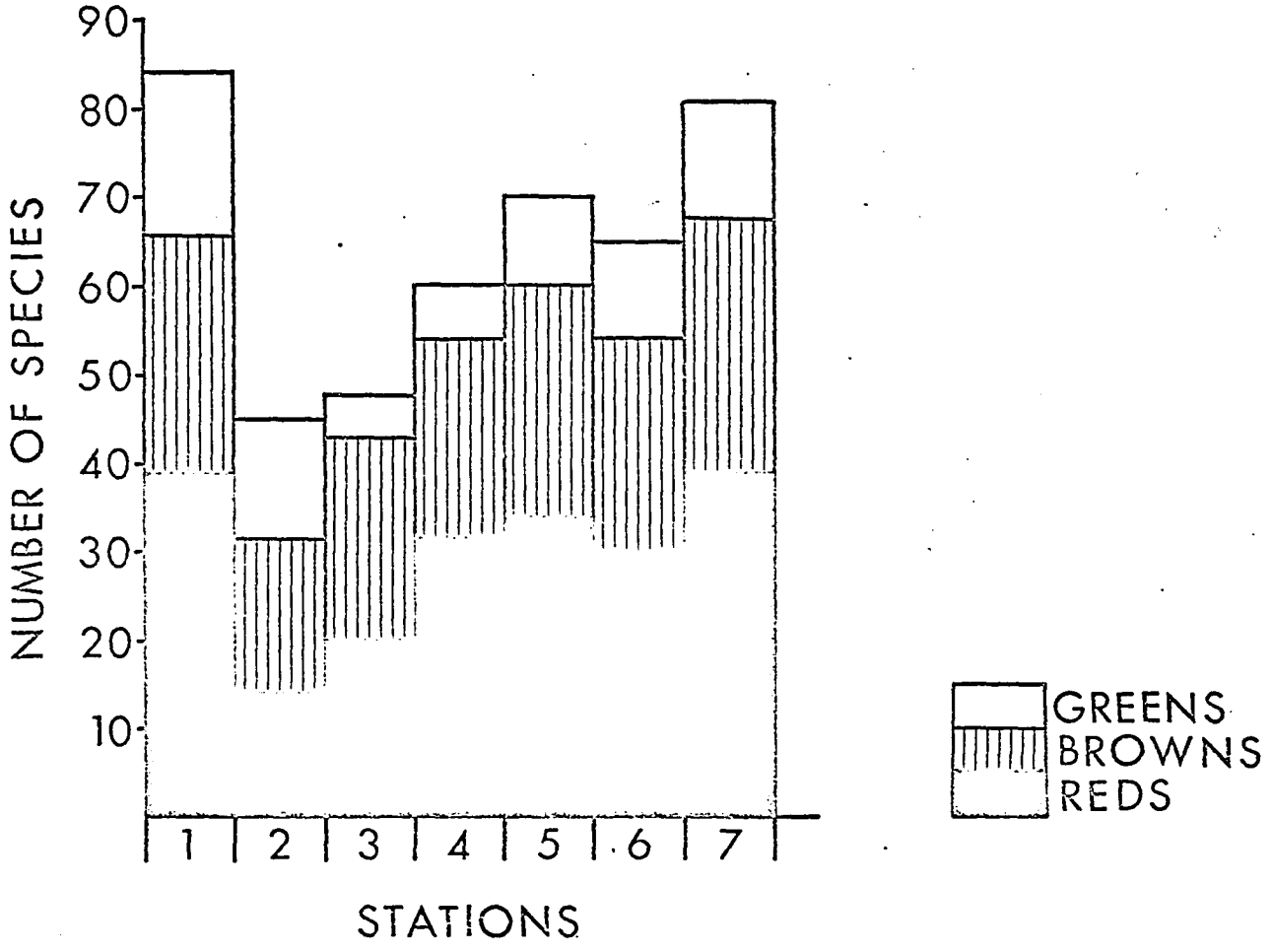
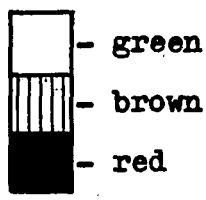

NUMBER OF SPECIES
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
STATIONS
GREENS
BROWNS
REDS

Figure 10. Monthly number of species at stations 1-3

Legend for Fig. 10-11



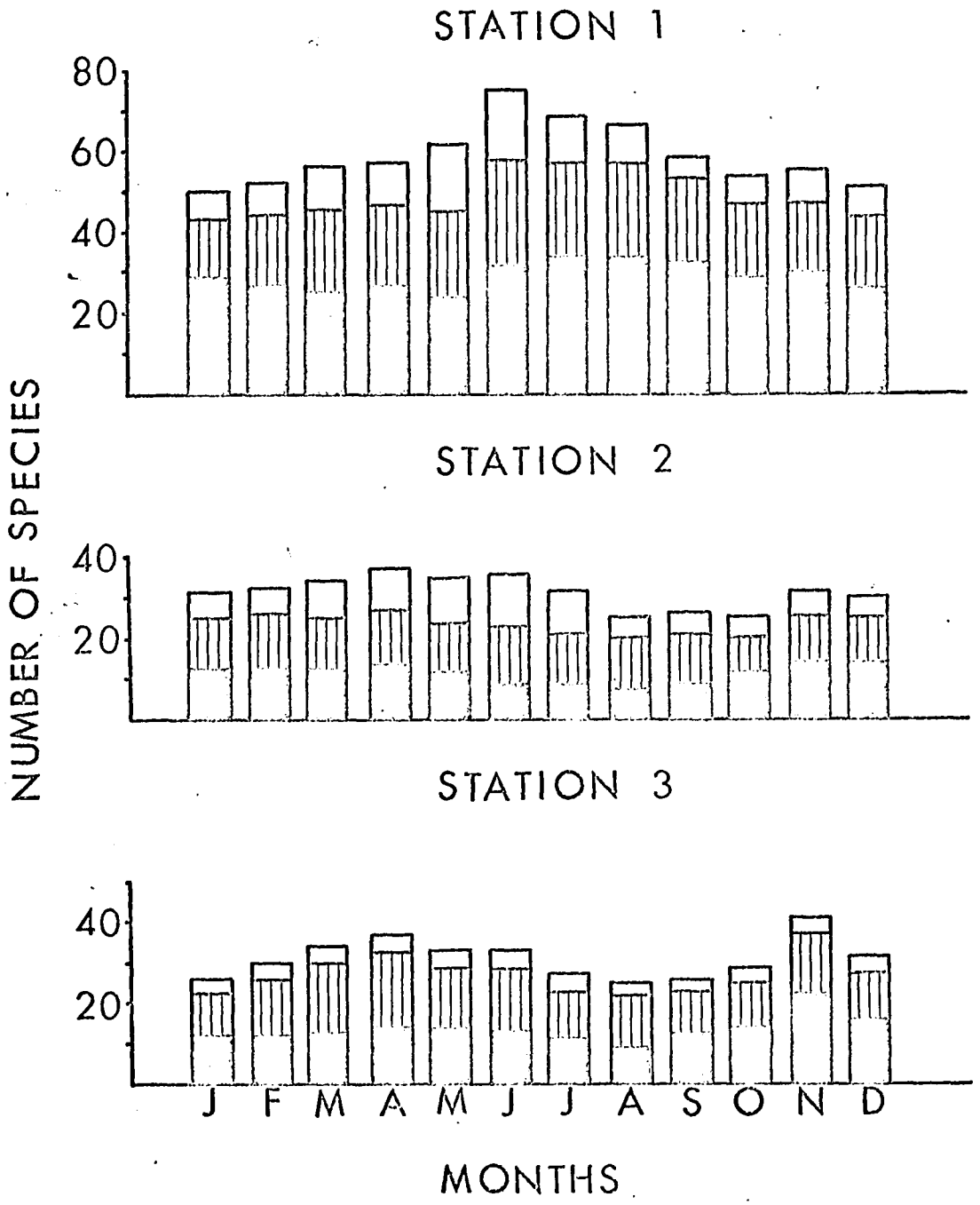

STATION 1
80
60
40
20
STATION 2
40
20
STATION 3
40
20
NUMBER OF SPECIES
J F M A M J J A S O N D
MONTHS

Figure 11. Monthly number of species at stations 4–7

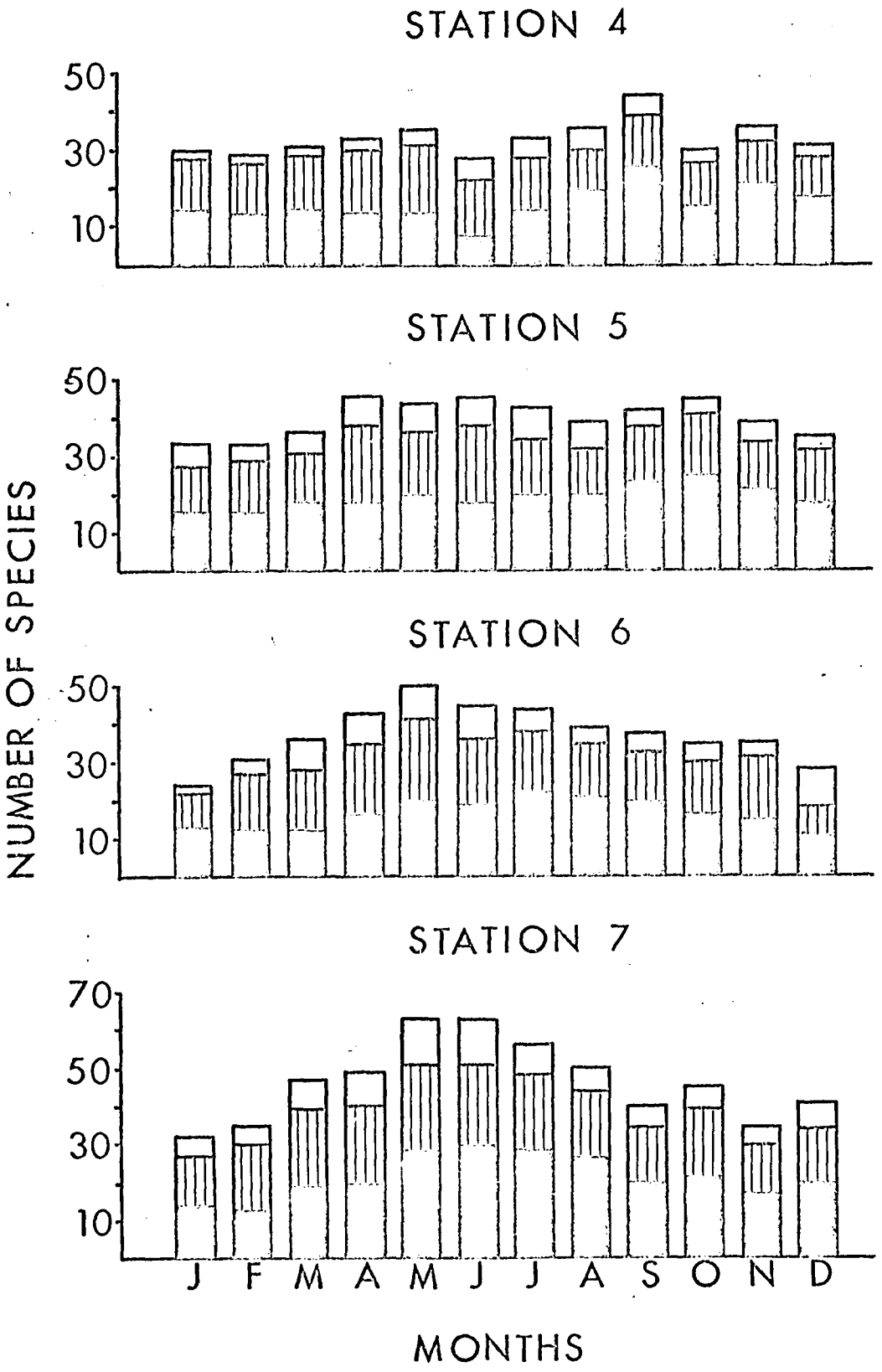

STATION 4
50
30
10
STATION 5
50
30
10
NUMBER OF SPECIES
STATION 6
50
30
10
STATION 7
70
50
30
10
J F M A M J J A S O N D
MONTHS

Figure 12. Number of annuals and perennials at each station

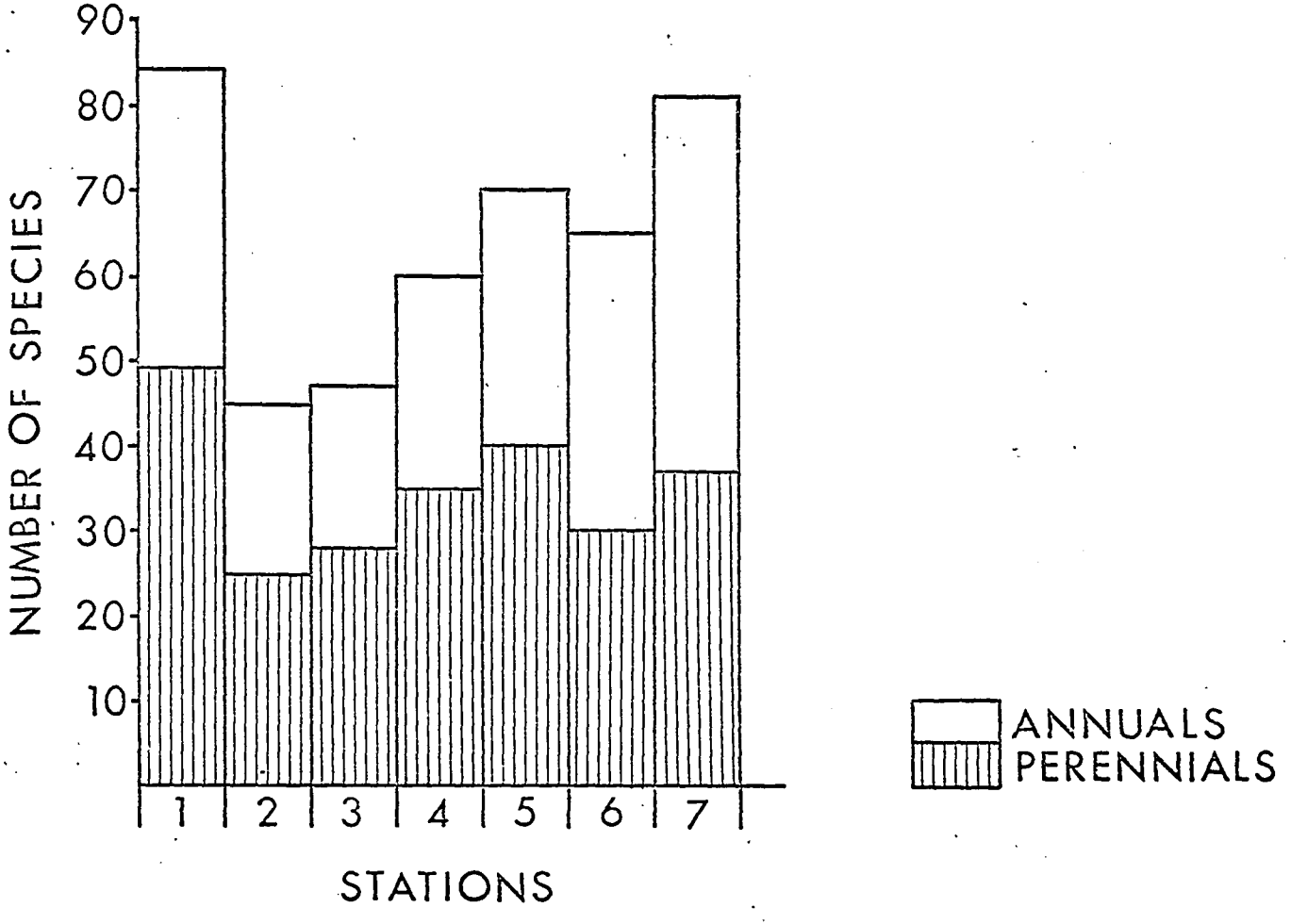

NUMBER OF SPECIES
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
STATIONS
ANNUALS
PERENNIALS

Figure 13. Monthly number of annuals at stations 1,4 and 7

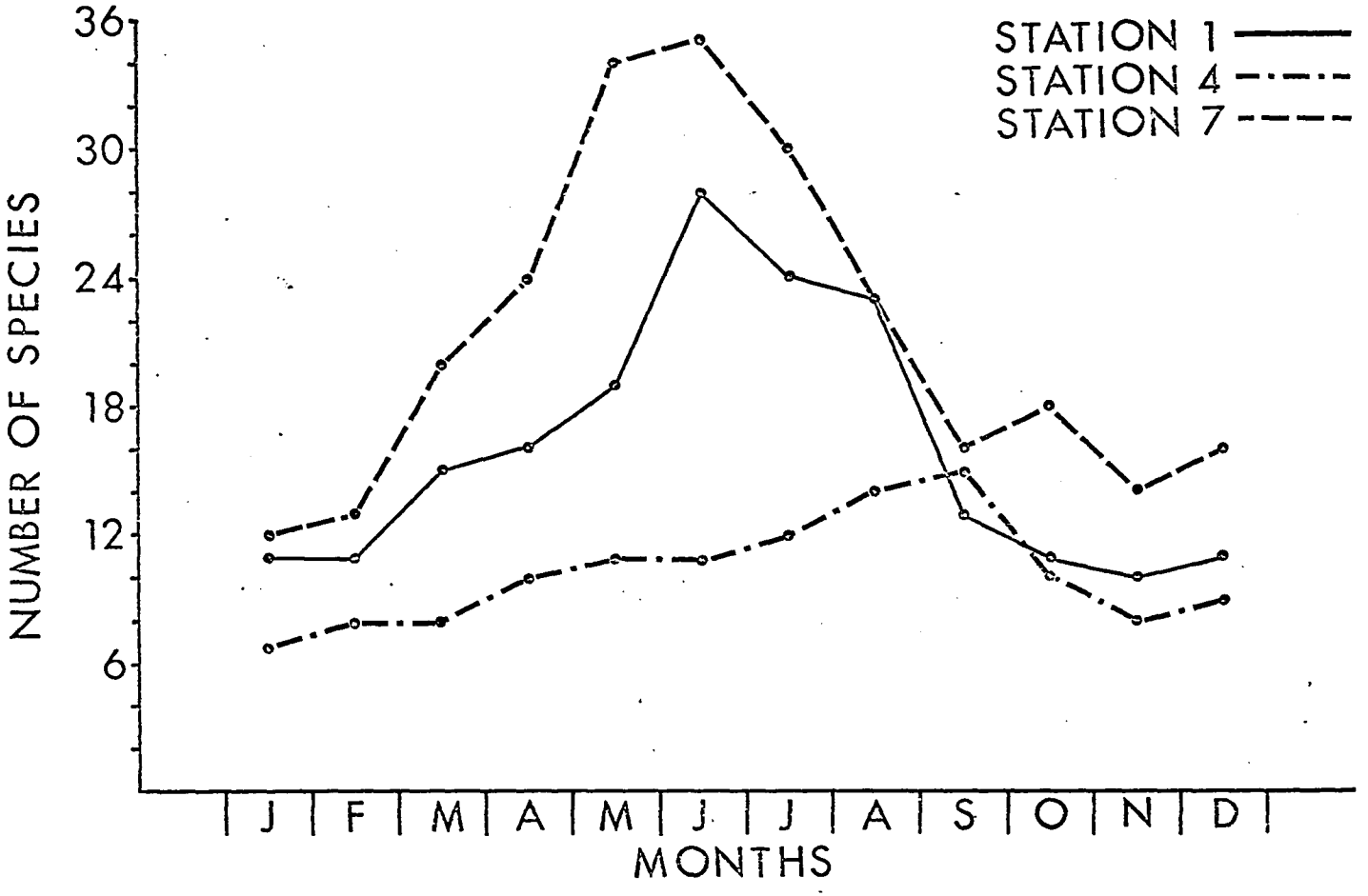

STATION 1
STATION 4
STATION 7
NUMBER OF SPECIES
36
30
24
18
12
6
J
F
M
A
M
J
J
A
S
O
N
D
MONTHS

Figure 14. Vertical distribution of species at each station

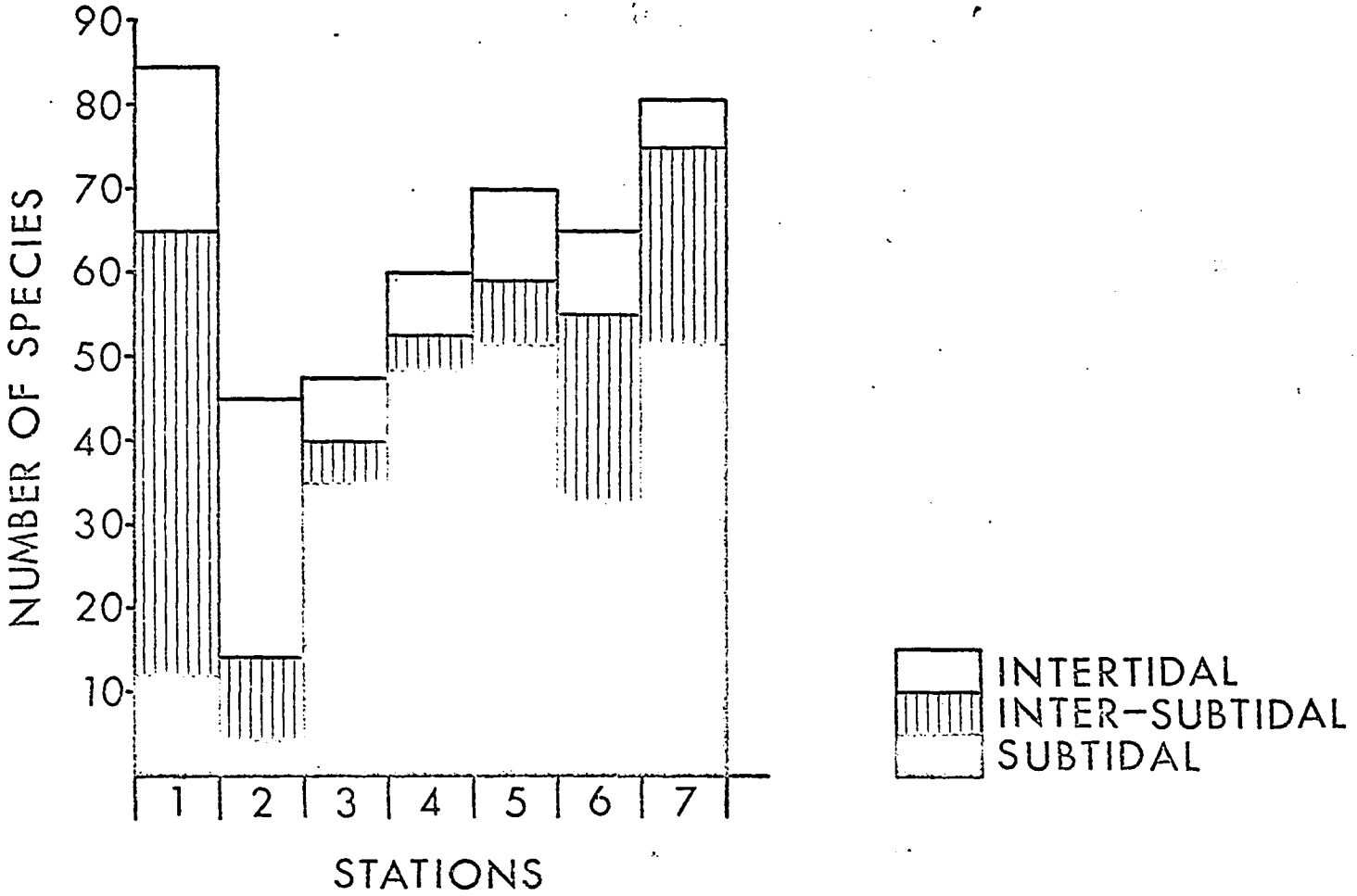

NUMBER OF SPECIES
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
STATIONS
INTERTIDAL
INTER-SUBTIDAL
SUBTIDAL

Table 1. Species composition, seasonality and reproductive periodicity of taxa at Station 1.

LEGEND FOR TABLES 1-7

a	=	alpha spores
b	=	beta spores
C	=	carospores
G	=	gametes
M	=	monospores
PG	=	plurilocular gametangia
PS	=	plurilocular sporangia
P	=	propagules
R	=	fertile
S	=	spermatia
T	=	tetraspores
V	=	seirospores
W	=	carpotetraspores
X	=	vegetative
Z	=	zoospores

RHODOPHYTA

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Agardhiella tenera	-	-	-	-	-	X	-	-	-	-	-	-
Ahnfeltia plicata	M	M	M	M	X	M	M	M	M	M	X	M
Bangia fuscopurpurea	M	M	X	X	X	M	X	-	-	-	X	M
Callithamnion baileyi	-	-	-	-	-	-	X	T	-	-	X	-
Callithamnion roseum	-	-	-	-	-	X	X	-	-	-	-	-
Ceramium rubrum	X	X	T	T	X	X	T	T,C	T	T	X	X
Ceramium strictum	-	-	-	-	-	-	X	X	X	-	-	-
Chondrus crispus	X	X	C	C	C	C	C	C	C	C	X	C
Choreocolax polysiphoniae	X	X	X	X	X	X	X	-	X	X	X	X
Clathromorphum circumscriptum	X	X	X	X	X	X	X	X	X	X	X	X
Corallina officinalis	X	X	X	X	X	X	X	X	X	X	X	X
Cystoclonium purpureum var. cirrhosum	X	X	X	X	X	X	T	T	T	T	T	X
Dermatolithon pustulatum	X	X	X	X	X	X	X	X	X	X	X	X
Dumontia incrassata	X	X	X	T	T	T	X	T	X	X	X	X
Gigartina stellata	C	C	C	C	X	X	C	C	C	C	C	C
Gloiosiphonia capillaris	-	-	-	-	-	X	X	X	-	-	-	-
Hildenbrandia prototypus	X	T	T	T	T	T	T	X	X	T	T	T
Lithophyllum corallinae	X	X	X	X	X	X	X	X	X	X	X	-
Lithothamnium graciale	X	X	X	X	X	X	X	X	X	X	X	X
Lomentaria baileyana	-	-	-	-	-	-	X	T	T	-	-	-
Melobesia lejolisii	-	-	-	-	-	X	X	X	X	X	X	X
Petrocelis middendorfii	T	T	T	T	X	T	X	X	X	X	X	X
Phyllophora brodiaei	W	W	X	X	W	W	W	X	X	X	X	W
Phyllophora membranifolia	T	T	T	T	X	X	X	X	X	T	X	T
Phymatolithon lenormandi	X	X	X	X	X	X	X	X	X	X	X	X
Plumaria elegans	X	X	X	X	X	X	X	X	-	X	X	X
Polyides rotundus	X	T	X	X	X	X	X	X	X	X	T	T
Polysiphonia dunudata	-	-	-	-	-	-	-	X	X	X	-	-
Polysiphonia harveyi	-	-	-	-	-	-	X	X	T	T	-	-
Polysiphonia lanosa	S	S	S	S	X	C	T,C	T	T,C	T,C	T	X
Polysiphonia nigrescens	X	-	X	-	-	T	T,C	T,C	C	T	T	T

RHODOPHYTA

Table 1 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Polysiphonia novae-angliae	T	T	-	X	-	-	-	-	X	-	X	-
Polysiphonia urceolata	X	X	-	X	-	T	-	T	T	-	T	T
Porphyra miniata	-	-	-	-	-	-	X	X	-	-	-	-
Porphyra umbilicalis	a	a	a,b	X	a	X	b	a,b	a	X	a,b	X
Rhodochorton penicilliforme	X	X	X	X	-	X	X	X	-	X	X	X
Rhodomela confervoides	X	X	X	X	T	T,C	T	T	X	X	X	X
Rhodymenia palmata	T	T	T	T	T	X	X	T	X	X	T	T
Trailliella intricata	-	-	-	-	-	-	-	X	X	-	-	-

PHAEOPHYTA

Table 1 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ascophyllum nodosum	R	R	R	R	R	R	R	R	R	R	R	R
Asperococcus echinatus	-	X	X	US	US	US	X	X	-	X	-	X
Chorda filum	-	-	-	-	-	X	US	US	US	-	-	-
Chorda tomentosa	X	X	X	US	US	X	X	-	-	-	-	-
Chordaria flagelliformis	X	X	X	X	X	US	US	X	US	X	US	X
Desmarestia aculeata	X	X	X	X	X	X	X	-	X	US	X	X
Desmarestia viridis	-	-	-	-	X	X	X	X	-	-	-	-
Desmotrichum balticum	-	-	-	-	-	PG	-	X	-	-	-	-
Dictyosiphon foeniculaceus	X	X	X	X	X	X	X	X	X	X	X	-
Ectocarpus siliculosus	X	-	-	-	-	PS	X	X	X	X	X	-
Elachista fucicola	X	X	X	X	X	X	US	US	X	US	US	US
Fucus distichus subsp. distichus	-	-	R	R	R	X	X	X	X	X	X	X
Fucus distichus subsp. edentatus	R	R	R	X	X	R	R	-	R	R	R	R
Fucus distichus subsp. evanescens	-	-	-	-	-	R	R	X	X	X	-	-
Fucus spiralis	R	X	X	R	R	R	R	X	R	R	R	X
Fucus vesiculosus	R	R	R	R	R	R	R	X	X	X	R	R
Laminaria digitata	US	US	US	US	X	X	X	X	X	X	X	US
Laminaria saccharina	US	US	US	X	X	X	X	X	X	X	US	US
Leathesia difformis	-	-	-	-	-	X	US	US	-	-	-	-
Myrionema strangulans	X	X	X	X	X	X	-	-	X	-	X	X
Petalonia fascia	PS	PS	PS	PS	PS	X	X	X	PS	PS	PS	X
Punctaria latifolia	-	-	-	-	-	X	-	-	-	-	-	-
Pilayella littoralis	US,PS	US,PS	US,PS	US,PS	US,PS	US,PS	US,PS	US,PS	US,PS	X	X	X
Ralfsia fungiformis	-	X	X	X	X	X	X	X	X	X	-	-
Ralfsia verrucosa	-	-	US	US	US	US	US	US	US	US	US	-
Scytosiphon lomentarius	PS	PS	PS	PS	PS	PS	-	PS	PS	X	X	PS
Sphacelaria cirrosa	X	X	X	X	X	P	P	P	P	P	P	X

CHLOROPHYTA

Table 1 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chaetomorpha atrovirens	X	X	X	-	X	X	X	X	X	X	X	X
Chaetomorpha linum	X	X	X	X	X	X	X	X	X	X	X	X
Chaetomorpha melagonium	-	X	X	X	X	X	X	X	-	X	X	X
Cladophora flexuosa	-	-	-	-	X	X	X	X	X	-	-	-
Cladophora gracilis	-	-	-	-	X	X	X	X	-	-	-	-
Codiolum petrocelidis	-	-	-	-	-	X	X	X	-	-	-	-
Codiolum gregarium	-	-	-	-	-	-	X	X	-	-	-	-
Enteromorpha intestinalis	X	X	X	X	X	X	X	X	X	X	X	X
Enteromorpha linza	-	-	-	-	X	X	-	-	-	-	-	-
Monostroma grevillei	-	-	X	G	X	X	-	-	-	-	-	-
Monostroma pulchrum	-	-	X	X	G	X	-	-	-	-	-	-
Rhizoclonium tortuosum	X	X	X	X	X	X	X	X	X	X	X	X
Spongomorpha arcta	-	-	X	X	X	X	X	-	-	-	-	-
Spongomorpha spinescens	-	-	-	-	X	X	X	-	-	-	-	-
Ulothrix flacca	X	X	Z	Z	X	X	-	-	-	-	X	X
Ulva lactuca	X	X	X	X	X	X	X	X	X	X	X	X
Urospora collabens	-	-	-	X	X	Z	-	-	-	-	-	-
Urospora penicilliformis	-	-	Z	Z	Z	X	X	X	-	-	-	-

Table II Species composition, seasonality and reproductive periodicity of taxa at station 2.

RHODOPHYTA

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ahnfeltia plicata	M	M	M	X	X	-	-	-	X	X	M	M
Bangia fuscopurpurea	M	X	M	M	M	M	-	-	-	-	X	M
Ceramium rubrum	X	X	T	T	X	T	X	T	X	X	T	T,C
Chondrus crispus	C	C	C	X	C	X	C	X	X	C	C	C
Choreocolax polysiphoniae	X	X	X	X	X	X	X	X	X	X	X	X
Dumontia incrassata	X	T	T	X	-	-	-	-	-	-	X	X
Hildenbrandia prototypus	T	T	T	X	X	X	X	X	T	T	X	T
Plumaria elegans	X	X	X	X	X	X	X	X	X	X	X	X
Polysiphonia harveyi	-	-	-	-	-	-	C	T	T,C	T,C	T	X
Polysiphonia lanosa	X	X	X	X	X	X	X	T	T	T	T	X
Polysiphonia nigrescens	-	-	-	X	-	-	-	-	-	-	-	-
Porphyra umbilicalis	a	a,b	X	a,b	X	-	-	-	-	a	a,b	X
Rhodochorton penicilliforme	T	T	X	T	X	X	X	-	-	X	X	T
Rhodymenia palmata	T	T	X	T	T	T	X	X	X	T	X	T

PHAEOPHYTA

Table 2 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ascophyllum nodosum	X	R	R	R	X	R	R	R	R	R	R	R
Chorda filum	-	-	-	-	-	X	US	US	US	-	-	-
Chorda tomentosa	-	X	X	X	US	US	-	-	-	-	-	-
Chordaria flagelliformis	-	-	-	X	X	US	US	US	X	X	X	-
Desmarestia aculeata	X	X	X	-	-	-	-	X	X	X	X	-
Ectocarpus siliculosus	X	X	X	X	X	US	PS	X	X	US	PS	X
Elachista fucicola	X	US	X	US	US	X	US	X	US	US	X	X
Fucus distichus subsp. edentatus	X	X	R	R	-	-	-	-	-	-	X	-
Fucus distichus subsp. evanescens	R	R	-	R	-	R	-	-	X	-	R	R
Fucus spiralis	R	R	X	R	R	R	X	X	X	-	R	R
Fucus vesiculosus	R	R	R	R	R	X	X	X	X	R	X	R
Laminaria saccharina	-	-	-	X	X	X	X	X	X	X	-	X
Petalonia fascia	PS	PS	X	PS	PS	-	-	-	-	-	X	X
Pilayella littoralis	US	US,PS	X	X	X	X	X	-	-	-	US	US
Ralfsia verucosa	X	X	X	X	X	X	US	US	X	US	-	X
Sargassum filipendula	-	-	-	-	-	-	-	-	-	X	-	-
Scytosiphon lomentarius	X	X	X	-	PS	X	PS	PS	-	-	X	X
Sphacelaria cirrosa	X	X	P	P	X	X	P	X	X	-	X	P

CHLOROPHYTA

Table 2 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chaetomorpha linum	X	X	X	X	X	X	X	X	X	X	X	X
Chaetomorpha melagonium	X	X	X	X	-	-	X	-	-	X	X	X
Codiolum gregarium	-	-	-	-	-	X	Z	Z	Z	-	-	-
Enteromorpha intestinalis	X	X	X	X	X	X	X	X	X	X	X	X
Enteromorpha linza	-	-	-	-	-	X	X	-	-	-	-	-
Monostroma grevillei	-	-	-	X	X	X	-	-	-	-	-	-
Monostroma pulchrum	-	-	X	X	X	G	-	-	-	-	-	-
Rhizoclonium tortuosum	X	X	X	X	X	X	X	X	X	X	X	X
Spongomorpha arcta	-	-	-	X	X	X	X	-	-	-	-	-
Spongomorpha spinescens	-	-	-	X	X	X	X	-	-	-	-	-
Ulothrix flacca	X	X	X	Z	Z	Z	-	-	-	-	-	-
Ulva lactuca	X	X	X	X	X	X	X	X	X	X	X	X
Urospora penicilliformis	-	-	Z	Z	X	Z	X	-	-	-	-	-

Table III Species composition, seasonality and reproductive periodicity of taxa at station 3.

RHODOPHYTA

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Agardhiella tenera	-	-	-	X	X	T	X	X	T	X	-	-
Ahnfeltia plicata	M	M	M	X	-	-	X	-	-	X	M	M
Ceramium rubrum	T	T	X	X	T	X	X	X	X	T	T	T
Chondrus crispus	C	C	C	C	C	X	X	X	C	C	C	C
Choreocolax polysiphoniae	X	X	X	-	X	X	-	-	-	X	X	X
Corallina officinalis	X	X	X	-	X	-	-	-	X	-	X	-
Cystoclonium purpureum var. cirrhosum	X	X	-	-	X	-	-	-	T	-	T	X
Dasya pedicellata	-	-	-	-	-	X	X	T	T	T	X	X
Dumontia incrassata	X	X	X	X	T	X	-	-	-	-	X	X
Grinnellia americana	-	-	-	-	-	-	-	-	T	T	T	T
Phyllophora membranifolia	T	X	T	T	X	X	X	-	X	X	T	X
Polyides rotundus	T	T	X	T	-	X	X	X	-	X	X	T
Polysiphonia denudata	-	-	-	-	-	-	X	T	X	T	T,C	X
Polysiphonia elongata	X	X	X	X	X	X	-	-	X	T	X	X
Polysiphonia lanosa	X	X	X	X	X	X	-	X	X	T,C	T	X
Polysiphonia nigrescens	-	-	-	X	X	-	-	-	-	-	-	X
Polysiphonia urceolata	-	-	-	X	X	-	T	-	-	T	T	X
Porphyra umbilicalis	-	-	a	a	a,b	X	-	-	-	-	-	-
Rhodomela confervoides	-	-	X	X	-	T	T	X	-	-	X	-
Rhodymenia palmata	T	T	T	T	T	X	X	X	X	T	T	T

PHAEOPHYTA

Table 3 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ascophyllum nodosum	R	R	R	R	R	X	X	R	R	R	R	R
Asperococcus echinatus	X	X	-	US	X	US	-	-	X	-	X	-
Chorda filum	-	-	-	X	US	US	US	US	X	X	-	-
Chorda tomentosa	X	X	US	X	-	-	-	-	-	-	X	X
Chordaria flagelliformis	-	X	X	US	US	US	US	-	X	US	-	X
Desmarestia aculeata	-	-	X	X	-	X	-	-	-	US	US	-
Desmarestia viridis	-	-	X	X	X	X	X	-	-	-	-	-
Desmotrichum balticum	-	-	-	-	X	-	-	-	-	-	-	-
Ectocarpus siliculosus	-	-	X	X	X	X	PS	X	X	X	X	-
Elachista fucicola	X	X	US	US	X	US	X	X	X	X	US	X
Fucus distichus subsp. evanescens	X	X	R	R	X	-	-	-	-	-	X	X
Fucus spiralis	-	R	R	X	R	R	X	X	R	R	X	X
Fucus vesiculosus	X	R	R	R	R	R	X	X	X	X	X	X
Laminaria saccharina	US	US	US	US	X	X	X	X	X	X	US	US
Leathesia difformis	-	-	-	US	US	US	US	X	-	-	-	-
Myrionema strangulans	X	X	X	-	-	-	-	X	-	-	X	-
Petalonia fascia	-	X	X	-	-	-	-	-	-	-	-	X
Punctaria latifolia	-	-	-	X	-	-	-	-	-	-	-	-
Pilayella littoralis	US,PS	US,PS	X	US	X	US	-	X	X	-	X	-
Ralfsia verrucosa	X	-	X	X	-	-	US	US	-	-	X	-
Sargassum filipendula	-	-	-	-	-	X	X	X	-	X	-	-
Scytosiphon lomentarius	PS	PS	X	PS	-	X	-	-	-	-	X	PS
Sphacelaria cirrosa	X	P	P	X	P	X	-	X	X	X	X	P

CHLOROPHYTA

Table 3 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chaetomorpha linum	X	X	X	X	X	X	X	X	X	X	X	X
Codium fragile subsp. tomentosoides	G	G	G	G	G	G	G	G	G	G	G	G
Enteromorpha intestinalis	X	X	X	X	X	X	X	-	-	X	X	X
Ulva lactuca	X	X	X	X	X	X	X	X	X	X	X	X

Table IV Species composition, seasonality and reprodutive periodicity of taxa at station 4.

RHODOPHYTA

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Agardhiella tenera	-	-	-	-	-	X	X	C	C	C	-	-
Ahnfeltia plicata	M	M	M	X	M	-	X	X	-	X	X	M
Bonnemaisonia hamifera	-	-	-	-	-	-	-	-	-	-	X	X
Callithamnion roseum	-	-	-	-	-	-	X	X	T	T	-	-
Ceramium rubrum	X	X	T	T	X	X	T	X	X	-	X	X
Ceramium strictum	-	-	-	-	-	-	T	T	T	-	-	-
Champia parvula	-	-	-	-	-	-	-	T	T	-	-	-
Chondrus crispus	C	C	X	C	C	C	X	X	C	C	C	C
Choreocolax polysiphoniae	X	X	-	X	-	-	-	-	X	X	-	-
Corallina officinalis	X	X	X	X	X	X	-	X	-	X	X	X
Cystoclonium purpureum var. cirrhosum	X	X	X	X	T,C	-	T	T,C	T	T,C	T,C	X
Dumontia incrassata	X	X	T	T	T	T	-	-	-	-	-	X
Goniotrichum alsidii	-	-	-	-	-	-	-	-	X	-	-	-
Grinnellia americana	-	-	-	-	-	-	-	T	T	T	-	-
Lomentaria orcadensis	-	-	-	-	-	-	-	-	T	T	X	X
Melobesia lejolisii	-	-	-	X	-	X	X	-	X	-	X	-
Phyllophora brodiaei	W	W	W	X	W	-	-	-	-	-	X	W
Phyllophora membranifolia	T	T	T	X	X	X	X	X	T	-	T	T
Polyides rotundus	T	T	T	-	X	-	X	-	X	-	T	T
Polysiphonia denudata	-	-	-	-	-	-	-	-	T,C	C	X	-
Polysiphonia elongata	X	-	X	-	-	-	-	-	T,C	T	X	X
Polysiphonia harveyi	-	-	-	-	-	-	X	T,C	T,C	C	X	-
Polysiphonia lanosa	X	X	-	X	X	-	-	T,C	T,C	T	T,C	X
Polysiphonia nigrescens	-	-	X	-	-	-	T	T	X	-	X	X
Polysiphonia novae-angliae	-	-	-	-	-	-	-	X	T,C	-	-	-
Polysiphonia urceolata	-	-	-	-	X	T	T,C	-	X	-	X	X
Porphyra leucosticta	-	-	-	-	-	-	-	-	-	-	X	X
Porphyra umbilicalis	-	-	X	X	X	-	-	-	-	-	-	-
Rhodomela confervoides	X	X	X	-	-	-	-	T	T	-	X	X
Rhodymenia palmata	T	T	T	T	T	T	X	T	T	T	T	X
Trailliella intricata	-	-	-	-	-	-	-	-	X	-	-	-

PHAEOPHYTA

Table 4 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ascophyllum nodosum	R	R	R	R	R	X	X	R	X	R	R	R
Asperococcus echinatus	-	X	X	US	-	-	-	X	-	-	-	X
Chorda filum	-	-	-	-	X	US	US	US	US	-	-	-
Chorda tomentosa	X	X	US	US	US	-	-	-	-	-	-	-
Chordaria flagelliformis	-	-	-	X	X	X	X	US	US	US	US	-
Desmarestia aculeata	X	X	X	X	X	X	X	-	X	X	X	-
Desmarestia viridis	-	-	-	X	X	X	X	-	-	-	-	-
Desmotrichum undulatum	-	-	-	US	-	-	-	-	-	-	-	-
Ectocarpus siliculosus	X	X	X	X	X	US	X	X	PS	PS	-	PS
Elachista fucicola	US	US	X	X	X	X	X	US	US	X	US	US
Fucus distichus subsp. evanescens	-	-	R	R	R	-	-	-	X	-	-	-
Fucus spiralis	R	R	R	X	R	X	X	-	R	R	X	X
Fucus vesiculosus	R	R	R	R	R	R	R	X	X	X	R	R
Giffordia granulosa	-	-	-	-	-	-	-	-	R	-	-	-
Laminaria digitata	-	-	-	X	-	-	-	-	-	-	-	-
Laminaria saccharina	US	US	US	US	X	X	X	X	X	X	US	X
Leathesia difformis	-	-	-	-	-	US	US	US	-	-	-	-
Myrionema strangulans	X	X	-	-	-	X	-	-	-	X	-	-
Petalonia fascia	PS	PS	X	X	PS	-	-	-	-	-	X	-
Pilayella littoralis	US	US,PS	US,PS	X	X	X	X	X	X	X	US	US
Ralfsia verrucosa	X	-	X	-	X	-	US	-	US	-	-	-
Scytosiphon lomentarius	PS	PS	PS	-	X	X	-	-	X	X	PS	PS
Sphacelaria cirrosa	X	P	P	X	P	X	X	X	-	X	P	P

CHLOROPHYTA

Table 4 — continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chaetomorpha linum	-	-	X	X	X	X	X	X	X	-	X	X
Chaetomorpha melagonium	-	-	-	-	-	X	X	X	-	-	-	-
Cladophora flexuosa	-	-	-	-	-	-	-	X	X	X	X	-
Codium fragile subsp. tomentosoides	-	-	-	G	G	G	G	G	G	G	G	-
Enteromorpha intestinalis	X	X	-	-	X	X	X	X	X	-	-	X
Ulva lactuca	X	X	X	X	X	X	X	X	X	X	X	X

Table V Species composition, seasonality and reproductive periodicity of taxa at station 5.

RHODOPHYTA

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Agardhiella tenera	-	-	-	-	X	X	X	C	C	C	T	-
Ahnfeltia plicata	M	M	M	M	X	X	X	-	M	M	M	M
Bangia fuscopurpurea	M	M	M	X	-	-	-	-	-	-	X	M
Callithamnion roseum	-	-	-	-	T	T	-	-	C	X	T	T
Ceramium rubrum	X	X	X	X	X	X	X	T	X	X	X	X
Ceramium strictum	-	-	-	-	-	T,C	T	T	-	-	-	-
Chondrus crispus	C	C	C	C	X	X	X	X	C	X	X	X
Choreocolax polysiphoniae	X	X	X	-	X	-	-	-	X	-	X	X
Corallina officinalis	X	X	X	X	X	X	-	X	X	X	X	X
Cystoclonium purpureum var. cirrhosum	X	X	X	T,C	T	X	X	X	X	X	X	X
Dasya pedicellata	-	-	-	-	-	-	X	T	T	T	X	-
Dumontia incrassata	X	X	X	T	T	T	X	X	-	-	-	-
Gloiosiphonia capillaris	-	-	-	-	-	-	X	X	-	-	-	-
Goniotrichum alsidii	-	-	-	-	-	-	X	-	-	-	-	-
Grinnellia americana	-	-	-	-	-	-	T	T	T	T	T	-
Hildenbrandia prototypus	-	-	T	X	-	-	-	-	-	-	-	X
Lomentaria baileyana	-	-	-	-	-	X	-	T	T	X	-	-
Lomentaria orcadensis	-	-	X	-	-	-	X	X	X	X	-	-
Phyllophora brodiaei	W	W	W	W	X	-	W	-	X	X	W	W
Phyllophora membranifolia	T	T	T	X	X	X	X	X	-	X	T	T
Polyides rotundus	T	X	X	X	X	X	-	X	X	X	X	T
Polysiphonia denudata	-	-	-	C	-	-	-	-	-	X	-	-
Polysiphonia elongata	X	X	X	-	X	-	X	T	T	T	T	X
Polysiphonia harveyi	-	-	-	-	X	X	X	T,C	T	T,C	T,C	X
Polysiphonia lanosa	X	X	X	X	X	C	X	T	T,C	T,C	T	X
Polysiphonia nigrescens	-	-	-	-	-	X	-	-	-	-	-	-
Polysiphonia novae-angliae	-	-	-	-	-	-	-	-	X	X	X	-
Polysiphonia urceolata	-	-	-	C	-	-	-	-	-	X	-	-
Porphyra miniata	-	-	-	a	X	-	-	-	X	-	-	-
Porphyra umbilicalis	-	-	-	-	a	a	X	X	X	X	a	-
Rhodomela confervoides	X	X	X	X	X	T	T	T	-	X	-	X
Rhodymenia palmata	T	T	T	T	T	T	X	X	X	X	T	X
Trailliella intricata	-	-	-	-	-	-	-	-	X	X	-	-

PHAEOPHYTA

Table 5 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ascophyllum nodosum	R	R	R	R	X	R	R	X	R	R	R	R
Asperococcus echinatus	-	-	US	US	US	X	-	-	-	X	-	X
Chorda filum	-	-	-	US	US	US	US	US	US	X	-	-
Chorda tomentosa	X	X	US	US	US	X	-	-	-	-	X	X
Chordaria flagelliformis	-	-	-	X	US	US	X	X	X	X	X	-
Desmarestia aculeata	X	X	X	X	X	X	-	-	X	US	-	-
Desmarestia viridis	-	-	-	X	X	X	X	-	-	-	-	-
Ectocarpus siliculosus	-	-	-	X	X	US	US	PS	PS	PS	US	US
Elachista fucicola	US	X	X	X	X	X	US	X	X	US	US	US
Fucus distichus subsp. edentatus	-	-	-	X	-	-	-	-	-	-	-	-
Fucus distichus subsp. evanescens	-	-	-	-	-	X	-	-	-	-	-	-
Fucus spiralis	R	X	R	R	X	-	-	-	R	R	R	X
Fucus vesiculosus	X	R	R	R	R	R	X	X	R	X	R	R
Fucus vesiculosus V. sphaerocarpus	-	-	-	-	-	R	R	X	-	-	-	-
Giffordia granulosa	-	-	-	X	-	-	-	-	-	-	R	-
Laminaria saccharina	X	US	US	X	X	X	X	R	X	X	US	X
Leathesia difformis	-	-	-	-	-	US	US	US	X	-	-	-
Myrionema strangulans	X	X	-	X	-	-	X	-	X	X	-	-
Petalonia fascia	X	PS	PS	X	X	-	-	-	-	X	-	PS
Punctaria latifolia	-	-	-	-	-	US	-	-	-	-	-	-
Pilayella littoralis	US	US	US	US	US	X	X	X	-	US	US,PS	US,PS
Ralfsia verrucosa	-	X	X	X	X	-	US	US	US	-	-	X
Sargassum filipendula	-	-	-	-	-	R	X	X	X	X	-	-
Scytosiphon lomentarius	PS	PS	X	X	PS	X	-	-	X	X	PS	PS
Sphacelaria cirrosa	X	X	P	P	-	P	P	-	P	X	P	P
Sphaerotrichia divaricata	-	-	-	-	-	X	-	-	-	-	-	-

CHLOROPHYTA

Table 5 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chaetomorpha linum	X	X	X	X	X	X	X	X	X	-	X	X
Chaetomorpha melagonium	X	-	-	X	X	-	-	X	-	-	X	-
Cladophora flexuosa	-	-	-	-	-	X	X	X	-	-	X	-
Cladophora gracilis	-	-	-	-	-	-	-	-	-	X	-	-
Codium fragile ssp. tomentosoides	X	X	G	G	G	X	G	X	X	G	G	G
Enteromorpha intestinalis	X	X	X	X	X	X	X	X	X	X	X	X
Enteromorpha linza	-	-	-	X	X	X	X	X	-	-	-	-
Spongomorpha arcta	-	-	-	X	X	X	X	-	-	-	-	-
Ulva lactuca	X	X	X	X	X	X	X	X	X	X	X	X
Urospora penicilliformis	-	-	X	X	Z	Z	Z	-	-	-	-	-

Table VI Species composition, seasonality and reproductive periodicity of taxa at station 6.

RHODOPHYTA

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Agardhiella tenera	-	-	X	X	X	T,C	X	T,C	X	X	-	-
Ahnfeltia plicata	M	X	M	M	M	M	-	X	X	-	X	X
Bangia fuscopurpurea	M	M	X	X	X	-	-	-	-	-	X	-
Callithamnion baileyi	-	-	-	-	-	-	X	X	X	-	-	-
Callithamnion roseum	-	-	-	-	X	X	X	X	X	-	-	-
Ceramium rubrum	X	X	X	C	T,C	T	T	T	T	X	X	X
Ceramium strictum	-	-	X	X	T,C	X	-	-	-	-	-	-
Champia parvula	-	-	-	-	X	T	T	X	T	T	T	-
Chondria sedifolia	-	-	-	-	-	X	T	C	T	T	T	X
Chondrus crispus	C	C	C	C	C	X	X	X	X	C	C	C
Corallina officinalis	X	X	X	X	X	X	X	X	X	X	X	X
Cystoclonium purpureum var. cirrhosum	-	-	-	T	T,C	T	X	X	X	-	-	-
Dasya pedicellata	-	-	-	-	-	-	X	T	T	T	X	-
Dermatolithon pustulatum	X	X	X	-	X	X	X	X	X	X	-	X
Dumontia incrassata	X	X	T	T	T	X	-	-	-	-	-	-
Goniotrichum alsidii	-	-	-	-	X	-	-	-	-	-	-	-
Grinnellia americana	-	-	-	-	-	-	T	T	T	X	-	-
Hildenbrandia prototypus	-	T	T	X	-	-	-	-	-	-	X	-
Hypnea musciformis	-	-	-	-	-	X	T	T	X	X	-	-
Lomentaria baileyana	-	-	-	X	X	T	T	T	-	-	-	-
Melobesia lejolisii	X	X	X	X	X	X	X	X	X	X	X	X
Phyllophora membranifolia	T	T	T	T	X	X	X	-	X	X	T	T
Polyides rotundus	-	-	-	X	X	-	X	-	-	-	-	-
Polysiphonia harveyi	C	-	-	-	-	-	C	C	T,C	T,C	T,C	T,C
Polysiphonia lanosa	X	-	-	-	-	-	-	-	-	-	-	-
Polysiphonia nigrescens	X	C	-	-	-	X	T	X	T	C	T,C	X
Polysiphonia urceolata	X	T	-	-	C	-	-	-	X	X	-	X
Porphyra leucosticta	-	-	-	X	X	X	X	X	-	-	-	-
Porphyra umbilicalis	-	-	-	a	X	a	a	a	-	-	X	-
Trailliella intricata	-	-	-	-	-	-	X	X	X	X	X	-

PHAEOPHYTA

Table 6 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ascophyllum nodosum	R	R	R	R	R	X	X	R	R	R	R	R
Asperococcus echinatus	-	X	X	US	US	X	X	-	-	-	X	X
Chorda filum	-	-	-	-	US	X	X	US	US	X	US	X
Chorda tomentosa	X	X	US	US	US	-	-	-	-	-	-	X
Chordaria flagelliformis	-	-	-	US	X	US	X	X	US	X	-	-
Desmarestia viridis	-	-	-	-	X	X	X	-	-	-	-	-
Desmotrichum undulatum	-	-	US	US	US	US	X	X	X	-	-	-
Dictyosiphon foeniculaceus	-	X	-	X	X	X	X	X	X	X	X	X
Ectocarpus siliculosus	-	X	PS	US,PS	PS	-	PS	X	-	-	US,PS	X
Elachista fucicola	-	X	-	X	X	X	-	X	X	US	US	US
Fucus spiralis	-	X	X	X	-	-	-	-	-	X	X	-
Fucus vesiculosus V. sphaerocarpus	R	R	R	R	R	R	R	R	R	X	R	R
Leathesia difformis	-	-	-	X	US	US	US	-	-	-	-	-
Myrionema strangulans	-	-	-	X	-	X	X	-	-	X	-	-
Petalonia fascia	PS	PS	PS	PS	PS	-	-	-	-	X	X	PS
Punctaria latifolia	-	X	X	-	X	X	-	-	-	-	-	-
Punctaria plantaginea	-	-	US	US	US	X	X	X	-	-	-	-
Pilayella littoralis	US	US	US	X	US	PS	-	US	PS	US,PS	PS	US,PS
Ralfsia fungiformis	-	X	X	-	-	-	-	-	-	-	X	-
Ralfsia verrucosa	-	-	X	X	X	-	US	US	-	US	X	-
Sargassum filipendula	X	X	X	X	R	X	R	R	R	R	R	X
Scytosiphon lomentarius	PS	PS	PS	PS	PS	X	-	-	PS	X	X	X
Sphacelaria cirrosa	X	X	X	X	P	P	X	P	P	P	P	P
Sphaerotrichia divaricata	-	-	-	-	X	-	X	US	US	-	US	-

CHLOROPHYTA

Table 6 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chaetomorpha linum	X	X	X	-	X	X	X	X	X	X	X	X
Cladophora flexuosa	-	-	-	-	X	X	X	X	X	-	-	-
Cladophora gracilis	-	-	-	-	-	-	-	-	X	X	X	X
Codium fragile subsp. tomentosoides	X	X	X	G	G	X	X	G	G	G	G	G
Enteromorpha intestinalis	-	-	X	X	X	X	X	X	-	X	-	-
Monostroma grevillei	-	X	X	Z	Z	X	-	-	-	-	-	-
Monostroma pulchrum	-	-	X	Z	Z	X	X	-	-	-	-	-
Spongomorpha arcta	-	-	X	X	X	X	X	-	-	-	-	-
Ulothrix flacca	X	X	Z	Z	Z	Z	-	-	-	-	X	X
Ulva lactuca	-	-	-	-	-	-	-	-	X	X	-	-
Urospora penicilliformis	-	-	X	X	Z	X	-	-	-	-	-	-

Table VII Species composition, seasonality and reproductive periodicity of taxa at station 7.

RHODOPHYTA

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Agardhiella tenera	-	-	X	X	X	C	C	T	C	T	X	X
Ahnfeltia plicata	M	M	M	M	M	X	X	M	-	-	M	M
Antithamnion americanum	-	-	X	T	T	-	-	-	-	-	-	-
Bangia fuscopurpurea	M	M	M	X	X	X	-	-	-	-	X	M
Callithamnion baileyi	-	-	-	-	T	T	T	X	X	-	-	-
Callithamnion roseum	C	-	-	-	X	X	X	-	-	S	X	-
Ceramium rubrum	X	X	X	T	X	T	X	T,C	T	T,C	X	T,C
Ceramium strictum	-	-	-	X	C	T	T	X	-	-	-	-
Champia parvula	-	-	-	-	-	T	T	T	T	X	T	X
Chondria sedifolia	-	-	-	-	-	X	T	X	X	X	X	X
Chondrus crispus	C	C	C	C	C	X	X	X	X	X	C	C
Corallina officinalis	X	X	X	X	X	X	X	X	X	X	X	X
Cystoclonium purpureum var. cirrhosum	-	X	X	T,C	T,C	X	X	X	X	X	-	X
Dasya pedicellata	-	-	-	-	-	-	T	T,C	C	T,C	X	X
Dermatolithon pustulatum	X	X	X	X	X	X	X	X	X	X	X	X
Gloiosiphonia capillaris	-	-	-	X	X	-	-	-	-	-	-	-
Goniotrichum alsidii	-	-	-	-	X	-	-	-	-	-	-	-
Grinnellia americana	-	-	-	-	-	X	T	T	T	X	-	-
Hildenbrandia prototypus	T	T	T	X	T	-	-	-	-	X	X	T
Hypnea musciformis	-	-	-	-	-	T	T	X	X	X	-	-
Lomentaria baileyana	-	-	-	-	X	X	T	X	-	-	-	-
Melobesia lejolisii	X	X	X	X	X	X	X	X	X	X	X	X
Phyllophora brodiaei	-	-	-	-	-	-	-	X	-	-	-	-
Phyllophora membranifolia	X	C	C	X	X	X	X	X	X	X	X	X
Polyides rotundus	-	-	X	X	X	X	-	-	-	-	-	X
Polysiphonia denudata	-	-	-	-	-	-	X	T	T	T	-	-
Polysiphonia harveyi	-	-	-	X	T	X	X	T,C	T	C	T,C	C
Polysiphonia lanosa	X	-	-	-	-	-	-	X	-	-	-	-
Polysiphonia nigrescens	-	-	X	-	X	T	X	X	X	T	T	X
Polysiphonia novae-angliae	-	-	T	-	-	X	-	-	X	T	-	-

RHODOPHYTA

Table 7 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Polysiphonia urceolata	C	-	C	X	T,C	X	T,C	T,C	C	X	-	X
Porphyra leucosticta	-	-	-	-	X	X	-	-	-	-	-	-
Porphyra miniata	-	X	X	-	-	-	-	-	-	-	-	-
Porphyra umbilicalis	-	-	-	-	X	X	a	X	a,b	X	a	X
Rhodomela confervoides	-	-	-	X	X	X	X	-	-	-	-	-
Rhodymenia palmata	-	-	X	X	X	X	X	-	-	-	-	-
Seirospora griffithsiana	-	-	-	-	-	X	V	X	-	-	-	-
Trailliella intricata	-	-	-	-	X	X	X	X	-	-	-	-

PHAEOPHYTA

Table 7 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Ascophyllum nodosum	R	R	R	R	R	R	R	R	R	R	R	R
Asperococcus echinatus	-	US	US	X	US	X	X	X	-	-	-	X
Chorda filum	X	-	-	-	X	US	US	US	US	US	X	-
Chorda tomentosa	X	X	US	US	US	US	-	-	-	-	-	X
Chordaria flagelliformis	-	-	-	X	US	US	X	US	X	US	-	-
Desmarestia viridis	-	-	-	-	X	X	X	-	-	-	-	-
Desmotrichum balticum	-	-	US	-	-	-	-	US	-	-	-	-
Desmotrichum undulatum	-	-	US	US	US	X	X	X	X	-	-	-
Dictyosiphon foeniculaceus	X	X	X	X	X	X	X	X	X	X	-	-
Ectocarpus siliculosus	US,PS	X	X	US,PS	PS	PS	PS	X	X	PS	PS	PS
Elachista fucicola	X	X	X	X	US	US	US	US	X	US	US	X
Fucus spiralis	X	X	X	-	-	-	-	-	-	R	X	-
Fucus vesiculosus V. sphaerocarpus	R	X	R	R	R	X	X	R	R	R	R	R
Fucus vesiculosus V. spiralis	-	-	-	-	-	-	-	-	-	-	-	R
Giffordia granulosa	-	R	-	-	-	-	-	-	-	-	-	-
Giffordia secunda	-	-	-	-	X	-	PG	-	-	X	-	-
Laminaria saccharina	US	US	X	X	X	X	X	X	X	R	X	R
Leathesia difformis	-	-	-	X	US	US	US	-	-	-	-	-
Myrionema strangulans	-	-	X	X	X	-	-	X	-	X	-	-
Petalonia fascia	PS	PS	PS	X	PS	-	-	-	-	X	X	X
Punctaria latifolia	-	-	-	US	X	X	-	-	-	-	-	-
Punctaria plantaginea	-	-	X	US	X	US	X	X	-	-	-	-
Pilayella littoralis	US	US	US	US	US	X	X	X	X	X	X	US
Ralfsia fungiformis	-	X	X	-	-	-	-	-	-	-	-	X
Ralfsia verrucosa	-	X	X	X	X	X	US	US	X	X	-	-
Sargassum filipendula	X	X	R	X	R	X	R	R	R	R	X	X
Scytosiphon lomentarius	PS	PS	PS	PS	PS	PS	X	-	-	X	PS	PS
Sphacelaria cirrosa	X	X	P	P	P	P	P	X	P	P	P	X
Sphaerotrichia divaricata	-	-	-	-	-	X	X	US	US	US	-	-

CHLOROPHYTA

Table 7 -- continued

TAXA	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Chaetomorpha linum	-	-	-	-	X	X	X	X	X	X	X	X
Chaetomorpha melagonium	-	-	-	X	-	-	-	-	-	-	-	-
Cladophora flexuosa	-	-	-	-	X	X	X	X	X	X	X	X
Cladophora gracilis	-	-	-	-	-	-	X	X	X	X	X	X
Codium fragile subsp. tomentosoides	X	G	G	G	G	G	G	G	G	G	G	G
Enteromorpha intestinalis	X	X	X	X	X	X	X	X	X	X	X	X
Enteromorpha linza	-	-	-	-	X	X	X	-	-	-	-	-
Monostroma grevillei	-	-	X	Z	Z	X	X	-	-	-	-	-
Monostroma pulchrum	-	X	X	Z	Z	X	-	-	-	-	-	-
Spongomorpha arcta	-	-	X	X	X	X	-	-	-	-	-	-
Ulothrix flacca	X	X	Z	Z	Z	X	-	-	-	-	-	-
Ulva lactuca	X	-	X	X	X	X	X	X	X	X	X	X
Urospora penicilliformis	X	X	Z	Z	Z	X						X

Table VIII Monthly number of annual and perennial Chlorophyta at each station.

LEGEND FOR TABLES 8-10

A = annuals
P = perennials
T = total

	STA 1			STA 2			STA 3			STA 4			STA 5			STA 6			STA 7		
	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T
JAN	3	3	6	3	3	6	1	2	3	2	0	2	2	3	5	1	2	3	4	1	5
FEB	3	4	7	3	3	6	2	2	4	2	0	2	2	2	4	2	2	4	4	1	5
MAR	7	4	11	5	3	8	2	2	4	1	1	2	3	2	5	6	2	8	7	1	8
APR	8	3	11	8	3	11	2	2	4	1	2	3	5	3	8	6	1	7	7	2	9
MAY	10	6	16	8	2	10	2	2	4	2	2	4	5	3	8	6	3	9	8	3	11
JUN	11	6	17	10	2	12	2	2	4	2	3	5	5	3	8	6	3	9	8	3	11
JUL	7	6	13	7	3	10	2	2	4	2	3	5	5	3	8	3	3	6	4	4	8
AUG	5	6	11	3	2	5	1	2	3	2	4	6	3	4	7	1	3	4	2	4	6
SEP	2	4	6	3	2	5	1	2	3	2	3	5	2	2	4	1	4	5	2	4	6
OCT	2	4	6	2	3	5	2	2	4	1	2	3	2	2	4	2	3	5	2	4	6
NOV	3	4	7	2	3	5	2	2	4	1	3	4	2	4	6	1	3	4	2	4	6
DEC	3	4	7	2	3	5	2	2	4	2	1	3	2	2	4	1	3	4	3	4	7

Table IX Monthly number of annual and perennial Rhodophyta at each station.

	STA 1			STA 2			STA 3			STA 4			STA 5			STA 6			STA 7		
	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T
JAN	3	25	28	3	9	12	1	11	12	1	13	14	2	14	16	3	10	13	3	10	13
FEB	3	24	27	3	9	12	2	10	12	1	12	13	2	14	16	2	10	12	3	9	12
MAR	3	23	26	3	9	12	2	11	13	2	12	14	2	16	18	4	8	12	5	14	19
APR	3	24	27	3	10	13	3	11	14	2	11	13	4	14	18	7	9	16	7	13	20
MAY	3	21	24	2	9	11	3	11	14	2	11	13	6	14	20	10	10	20	13	15	28
JUN	6	25	31	1	8	9	4	9	13	2	6	8	7	11	18	10	9	19	15	15	30
JUL	9	25	34	1	8	9	3	8	11	5	9	14	9	11	20	12	10	22	15	13	28
AUG	9	25	34	1	7	8	3	6	9	7	12	19	9	11	20	12	9	21	13	13	26
SEP	6	26	32	1	8	9	4	8	12	9	16	25	9	14	23	9	11	20	9	11	20
OCT	4	24	28	2	9	11	4	8	12	6	9	15	9	16	25	6	10	16	10	11	21
NOV	3	27	30	4	9	13	5	17	22	4	17	21	7	14	21	7	8	15	8	9	17
DEC	3	24	27	4	9	13	4	12	16	2	16	18	3	15	18	2	9	11	8	12	20

Table X Monthly number of annual and perennial Phaeophyta at each station.

	STA 1			STA 2			STA 3			STA 4			STA 5			STA 6			STA 7		
	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T	A	P	T
JAN	5	11	16	3	10	13	3	8	11	4	10	14	3	9	12	3	5	8	5	9	14
FEB	5	13	18	4	10	14	5	9	14	5	9	14	3	10	13	6	9	15	6	12	18
MAR	5	15	20	4	9	13	6	11	17	5	10	15	4	9	13	8	8	16	8	12	20
APR	5	15	20	4	10	14	9	10	19	7	10	17	8	12	20	9	10	19	10	10	20
MAY	6	15	21	5	8	13	7	8	15	7	11	18	8	8	16	13	8	21	13	10	23
JUN	11	16	27	5	9	14	7	9	16	7	8	15	10	10	20	9	8	17	12	9	21
JUL	8	14	22	4	8	12	5	7	12	5	9	14	5	10	15	9	7	16	11	9	20
AUG	9	13	22	4	8	12	3	10	13	5	6	11	4	8	12	6	8	14	8	10	18
SEP	5	16	21	3	9	12	4	7	11	4	10	14	5	10	15	5	7	12	5	9	14
OCT	5	15	20	2	7	9	3	8	11	3	9	12	6	10	16	4	10	14	6	12	18
NOV	4	14	18	4	9	13	4	11	15	3	8	11	4	8	12	6	10	16	4	8	12
DEC	5	12	17	3	9	12	4	7	11	3	7	10	5	8	13	6	7	13	5	9	14

Table XI Dominant annuals north and south of the Canal.

NORTH	SOUTH
Bangia fuscopurpurea	Agardhiella tenera
Dumontia incrassata	Antithamnion americanum
Lomentaria baileyana	Bangia fuscopurpurea
Polysiphonia harveyi	Callithamnion roseum
Porphyra umbilicalis	Ceramium strictum
	Champia parvula
	Chondria sedifolia
	Dasya pedicellata
	Dumontia incrassata
	Grinnellia americana
	Hypnea musciformis
	Lomentaria baileyana
	Polysiphonia harveyi
	Porphyra umbilicalis
	Seirospora griffithsiana
	Trailliella intricata
Asperococcus echinatus	Asperococcus echinatus
Chorda filum	Chorda filum
Chorda tomentosa	Chorda tomentosa
Chordaria flagelliformis	Chordaria flagelliformis
Ectocarpus siliculosus	Desmotrichum undulatum
Leathesia difformis	Ectocarpus siliculosus
Petalonia fascia	Leathesia difformis
Scytosiphon lomentarius	Petalonia fascia
	Punctaria latifolia
	Punctaria plantaginea
	Scytosiphon lomentarius
	Sphaerotrichia divaricata
Codiolum petrocelidis	Enteromorpha intestinalis
Enteromorpha intestinalis	Monostroma grevillei
Monostroma grevillei	Monostroma pulchrum
Monostroma pulchrum	Spongomorpha arcta
Spongomorpha arcta	Ulothrix flacca
Spongomorpha spinescens	Urospora penicilliformis
Ulothrix flacca	
Ulva lactuca	
Urospora collabens	
Urospora penicilliformis	

Table XII Dominant perennials north and south of the Canal.

NORTH	SOUTH
Ahnfeltia plicata	Callithamnion baileyi
Ceramium rubrum	Ceramium rubrum
Chondrus crispus	Chondrus crispus
Choreocolax polysiphoniae	Corallina officinalis
Clathromorphum circumscriptum	Cystoclonium purpureum
Corallina officinalis	var. cirrhosum
Cystoclonium purpureum	Melobesia lejolisii
var. cirrhosum	Phyllophora membranifolia
Gigartina stellata	Polysiphonia nigrescens
Hildenbrandia prototypus	Polysiphonia urceolata
Lithophyllum corallinae	
Petrocelis middendorfii	
Phyllophora membranifolia	
Phymatolithon lenormandi	
Plumaria elegans	
Polyides rotundus	
Polysiphonia lanosa	
Polysiphonia nigrescens	
Polysiphonia urceolata	
Rhodochorton penicilliforme	
Rhodomela confervoides	
Rhodymenia palmata	
Ascophyllum nodosum	Ascophyllum nodosum
Desmarestia aculeata	Dictyosiphon foeniculaceus
Elachista fucicola	Elachista fucicola
Fucus distichus	Fucus vesiculosus
subsp. distichus	V. sphaerocarpus
Fucus distichus	Pilayella littoralis
subsp. edentatus	Sargassum filipendula
Fucus spiralis	Sphacelaria cirrosa
Fucus vesiculosus	
Laminaria digitata	
Laminaria saccharina	
Pilayella littoralis	
Ralfsia fungiformis	
Ralfsia verrucosa	
Sphacelaria cirrosa	
Chaetomorpha atrovirens	Chaetomorpha linum
Chaetomorpha linum	Cladophora flexuosa
Chaetomorpha melagonium	Cladophora gracilis
Rhizoclonium tortuosum	Codium fragile
	subsp. tomentosoides

Table XIII Patterns of seasonal occurrence of annuals.

ANNUALS OCCURRING EARLIER SOUTH THAN NORTH OF CAPE

Agardhiella tenera	Chorda filum	Monostroma pulchrum
Ceramium strictum	Desmotrichum balticum	Urospora penicilliformis
Gloiosiphonia capillaris	Ectocarpus siliculosus	Monostroma grevillei
Lomentaria baileyana	Leathesia difformis	
Polysiphonia denudata	Punctaria latifolia	
Polysiphonia harveyi		
Porphyra miniata		

ANNUALS DISAPPEARING EARLIER SOUTH THAN NORTH OF CAPE

Bangia fuscopurpurea	Chorda tomentosa	Urospora penicilliformis
Ceramium strictum	Chordaria flagelliformis	
Dumontia incrassata	Desmarestia viridis	
Gloiosiphonia capillaris	Leathesia difformis	
Lomentaria baileyana	Petalonia fascia	
Porphyra miniata	Scytosiphon lomentarius	
Porphyra umbilicalis		

ANNUALS FOUND ALL YEAR ON BOTH SIDES OF CAPE

Asperococcus echinatus	Enteromorpha intestinalis
Scytosiphon lomentarius	Ulva lactuca

Table XIV Patterns of reproductive periodicities of annuals.

ANNUALS REPRODUCING EARLIER SOUTH THAN NORTH

Agardhiella tenera	Asperococcus echinatus
Ceramium strictum	Chorda filum
Dumontia incrassata	Chorda tomentosa
Lomentaria baileyana	Chordaria flagelliformis
Polysiphonia harveyi	Desmotrichum balitcum
	Ectocarpus siliculosus
	Elachista fucicola
	Leathesia difformis

ANNUALS TERMINATING REPRODUCTION EARLIER SOUTH THAN NORTH

Bangia fuscopurpurea	Asperococcus echinatus	Monostroma grevillei
Dumontia incrassata	Leathesia difformis	
Lomentaria baileyana	Petalonia fascia	
Porphyra umbilicalis		

ANNUALS REPRODUCING THROUGHOUT THE YEAR NORTH OF THE CAPE WITH LIMITED REPRODUCTIVE PERIODS SOUTH OF THE CAPE

Porphyra umbilicalis	Petalonia fascia
	Scytosiphon lomentarius

APPENDIX

Rhodophyceae

Bangiophycidae

Goniotrichales

Goniotrichaceae:

Goniotrichum alsidii (Zanardini) Howe

Uncommon, collected once at stations 4,5,6 and 7. Epiphyte on coarse algae and Zostera in the subtidal zone. Appearing in the spring south of the Cape and in the summer in the Canal. #4

Bangiales

Bangiaceae:

Bangia fuscopurpurea (Dillwyn) Lyngbye

Common on high intertidal rocks during the winter and spring at stations 1,2 and 7; uncommon in the Canal. Disappearing in May south of the Cape but remaining until late summer at station 1 and 2. Associated with Urospora penicilliformis, Ulothrix flacca and Codiolum gregarium. A winter annual persisting with reduced spring populations. Monospores found in each collection. #14

Porphyra leucosticta Thuret

Common at stations 6 and 7; uncommon in the Canal and at station 1. Found in the lower intertidal and subtidal zones on coarse algae such as Chondrus crispus and Fucus spp. A

spring annual present at stations 6 and 7 in early spring and during late spring at station 1. #9

Porphyra miniata (C. Agardh) C. Agardh
Common in the lower intertidal and upper subtidal zones at stations 1,6 and 7. Uncommon in the Canal. Epiphytic on Chondrus crispus, Gigartina stellata and other coarse algae. An annual present in the early spring at stations 6 and 7, but not until July or August at station 1. Alpha and beta spores found in each collection. #1

Porphyra umbilicalis (L.) J. Agardh
Common at all stations, except 3,4 and 6. Present in the mid to upper intertidal zone. An annual that is most abundant during the winter and spring. It is present in reduced numbers during summer and fall at station #1, but it disappears in late spring at all other stations. Beta spores found on each collection. #10

Floridiophycidae
Nemalionales
Acrochaetiaceae:
Rhodochorton penicilliforme (Lightfoot) Rosenvinge
Common at stations 1 and 2; rare at the remaining stations. Found in the mid-lower intertidal zone on rocks beneath thick growths of Ascophyllum nodosum or Fucus vesiculosus. A perennial plant. Tetraspores produced during the winter and early spring. #4

Bonnemaisoniacae:

Bonnemaisonia hamifera Hariot

(= Asparagopsis hamifera in Taylor, 1957) Collected twice at station 4. Found as an epiphyte on coarse algae or attached to rocks. Perennial? Reproductive during the summer. #15

Cryptonemiales

Dumontiaceae:

Dumontia incrassata (Müller) Lamouroux

Common at all stations during the colder months. Growing attached to rocks and mussels from the mid intertidal to the upper subtidal zone. An annual that was first evident during the winter. It appeared in May at stations 6 and 7, and in June at the Canal stations. Reduced populations were still evident during the summer and fall at station 1. Tetraspores found during the spring. #3

Polyideaceae:

Polyides rotundus (Hudson) Greville

(= P. caprinus in Taylor, 1957) Common at all stations except 2 and 6. Present on rocks often covered by sand and silt in the deeper subtidal zone. Nemathecia found from November to February. #4

Hildenbrandiaceae:

Hildenbrandia prototypus Nardo

Common at all stations, except 6 and 7. Growing on rocks and shells in the lower intertidal and upper subtidal zones.

A perennial forming tetraspores throughout the year. #14

Corallinaceae:

Clathromorphum circumscriptum (Strømfelt) Foslie
(= Phymatolithon compactum in Taylor, 1957) Common at station 1; rare at all other stations. Found on rocks and shells in tide pools of the mid to lower intertidal zones, extending into the shallow subtidal. A perennial species. #1

Corallina officinalis L.
Common at most stations, except #2. It was especially conspicuous at stations 1 and 6. Attached to rocks in the mid intertidal to upper subtidal; most common in tide pools of the lower intertidal. It became bleached and unhealthy looking at stations 6 and 7 during July and August. #14

Melobesia lejolisii Rosanoff
(= Fosliella lejolisii in Taylor, 1957) Common at all stations; epiphytic on coarse algae and Zostera. Extending from the mid-intertidal into the subtidal zone; perennial. #16

Lithophyllum corallinae (Crouan) Heydrich
Common throughout the year at all stations, except at 6 and 7. A specific epiphyte on Corallina officinalis; perennial. #15

Dermatolithon pustulatum (Lamouroux) Foslie
(= Lithophyllum macrocarpum in Edelstein, McLachlan and Craigie, 1967) Common at all stations. Epiphytic on coarse algae such as Chondrus crispus, Phyllophora spp., and Ahnfeltia

plicata. Collected from the lower intertidal to the subtidal zone; perennial. #15

Lithothamnium graciale Kjellman
Only collected at station 1. Present on stones and shells from the lower intertidal to a depth of 15-20 meters; perennial. #1

Phymatolithon lenormandi (Areschoug) Adey
(= Lithothamnium lenormandi in Taylor, 1957) Only collected on rocks and shells at station 1. Extending from the lower intertidal zone into the subtidal zone; perennial. #6

Choreocolaceae:

Choreocolax polysiphoniae Reinsch
Common at stations 1 and 2 becoming progressively less abundant to the south. Epiphytic on Polysiphonia lanosa; perennial. #4

Gloiosiphoniaceae:

Gloiosiphonia capillaris (Hudson) Carmichael ex Berkeley
Uncommon at all stations, especially in the Canal. Found on rocks and shells in the lower intertidal and upper subtidal zones. Also in tide pools. An annual appearing in the spring at station 7, but not until the summer at station 1. Disappearing from all stations by late August. #4

Gigartinales

Cruoriaceae:

Petrocelis middendorfii (Ruprecht) Kjellman

Common at station 1; rare at the remaining stations. Found on rocks of the lower intertidal zone and extending into the subtidal zone. A perennial species. Tetraspores evident during the winter and early spring. #15

Solieriaceae:

Agardhiella tenera (J. Agardh) Schmitz

Common at all stations except #1. Growing on subtidal rocks in sandy areas. An annual? It appeared in the early spring at stations 6 and 7, during late spring at stations 4 and 5, and not until June at station 1. It disappeared in December. Tetraspores and carpospores found from June to October. #12

Rhodophyllidaceae:

Cystoclonium purpureum (Hudson) Batters var. cirrhosum Harvey

Common throughout the year at all stations, except during the summer at stations 6 and 7. Found on rocks and occassionally epiphytic on other algae; extending from the lower intertidal into the subtidal zone. A perennial species. Tetraspores found from July to November at station 1; tetraspores and carpospores from April to June at stations 6 and 7. #15

Hypneaceae:

Hypnea musciformis (Wulfen) Lamouroux

Only collected at stations 6 and 7. Found on rocks and shells

in the subtidal zone. An annual: exident from late spring to November. Tetraspores evident during the summer. #12

Phyllophoraceae:

Ahnfeltia plicata (Hudson) Fries

Common at all stations, except 6 and 7. Extending from the lower intertidal (often in tide pools) to the deep subtidal. A perennial species, but becoming reduced in stature at stations 6 and 7 during the summer. Monospores produced throughout the year. #5

Phyllophora brodiaei (Turner) Endlick

Common at all stations, except 6 and 7. Present on rocks and shells from the lower intertidal to the deep subtidal. A perennial species, but becoming reduced in stature at stations 6 and 7 during the summer. Carpotetraspores found throughout the year. #5

Phyllophora membranifolia (Goodenough et Woodward) J. Agardh

Distribution and seasonal occurrence as P. brodiaei. Tetraspores found from the fall to the early spring. #5

Gigartinaceae:

Chondrus crispus Stackhouse

Common at all stations. Present on rocks from the low intertidal to the mid subtidal. The fronds are bleached in appearance during the summer, particularly at stations 6 and 7. Cystocarps found all year. #5

Gigartina stellata (Stackhouse) Batters
Only collected at station 1. Growing on rocks from the mid intertidal to the subtidal fringe. A perennial species. Cystocarps evident throughout the year. #4

Rhodymeniales

Rhodymeniaceae:

Rhodymenia palmata (L.) Greville
Common at stations 1-5; less abundant at 6 and 7. Present on rocks or epiphytic on kelp from the lower intertidal zone to the mid subtidal (often in tide pools). A perennial species. Tetraspores found throughout the year except at stations 6 and 7 where limited reproduction was evident. #5

Champiaceae:

Lomentaria baileyana (Harvey) Farlow
Occassional at all stations. Found on rocks and shells in the subtidal zone. An annual; appearing during the spring at stations 6 and 7, but not until summer at the remaining stations. Tetraspores found during late summer. #16

Lomentaria orcadensis (Harvey) Collins ex Taylor
Collected at stations 4 and 5 on rocks and pier pilings in the subtidal zone. A perennial species? Tetraspores found in the late summer and early fall. #15

Champia parvula (C. Agardh) Harvey
Common at stations 6 and 7, rare in the Canal and not collected at station 1. Present on rocks in the lower intertidal

and subtidal zones. A summer annual. Tetraspores found from June to November. #13

Ceramiales

Ceramiaceae:

Antithamnion americanum (Harvey) Farlow

Uncommon; only collected at stations 6 and 7. Present in the subtidal zone on rocks and on other algae. A spring annual with reproductive stages evident during the same period. #5

Seirospora griffithsiana (Harvey) Dixon

Uncommon; only collected at station 7. Found in the subtidal zone on rocks or epiphytic on other algae. Seirospores found during July and August. #7

Trailliella intricata (J. Agardh) Batters

Uncommon, at stations 6 and 7; rare in the Canal. Present on rocks and on other algae in the lower intertidal zone and extending into the subtidal. A perennial species according to observations made in New Hampshire (A. C. Mathieson, personal communications)

Callithamnion baileyi Harvey

Common at stations 1,6 and 7; rare or not collected at the remaining stations. An epiphyte on coarse algae such as Chondrus crispus and Rhodymenia palmata in the lower intertidal and subtidal zones. A perennial species (?). Tetraspores found from early spring to July. #5

Callithamnion roseum (Roth) Lyngbye

Common at stations 1,4,5,6 and 7; rare at the remaining stations. An epiphyte on various algae in the lower intertidal and subtidal zones. Tetraspores and spermatia found from May to November. Carpospores found twice. #16

Griffithsia tenuis C. Agardh

Uncommon; collected only once at station 4. Present on rocks and epiphytic on other algae from the lower intertidal zone to the subtidal. A summer annual. #4

Plumaria elegans (Bonnemaison) Schmitz

Common at stations 1 and 2; absent at all other stations. Present in the lower intertidal and upper subtidal on vertical rock faces under fucoids. A perennial species. #5

Ceramium rubrum (Hudson) C. Agardh

Common at all stations. Present on rocks or epiphytic on various other algae from the mid intertidal to the subtidal zone. A perennial species. Tetraspores found all year, except during the summer south of the Cape. #14

Ceramium strictum Harvey

Uncommon; present at all stations except 2 and 3. Growing on rocks and epiphytic on other algae in the intertidal and subtidal zones. A spring annual at stations 6 and 7, but not occurring until the summer at the remaining stations. Tetraspores found from summer to early fall. #16

Delesseriaceae:

Grinnellia americana (C. Agardh) Harvey

Common at all stations, except 1 and 2. Present on rocks, pier pilings and epiphytic on various algae. A summer annual appearing earlier at station 7 than in the Canal. It remained longest at station 3. Tetraspores found throughout the summer. #11

Dasyceae:

Dasya pedicellata (C. Agardh) C. Agardh

Common at stations 3-7, but not collected at stations 1 and 2. Present on rocks in the subtidal zone. A summer annual appearing from July to December. Reproductive from mid-summer to late autumn. #16

Rhodomelaceae:

Chondria sedifolia Harvey

(= Chondriopsis dasyphylla V. sedifolia by Hoyt, 1920)

Common at stations 6 and 7, rare in the Canal and not collected at station 1. Present on rocks in the subtidal zone. A summer annual. Tetraspores found from July to November. #12

Polysiphonia denudata (Dillwyn) Greville ex Harvey in Hooker

Common at stations 6 and 7; uncommon at all other stations. Present on rocks and epiphytic on other algae in the lower intertidal and subtidal zones. A summer annual. Tetraspores found during summer and early fall. #16

Polysiphonia elongata (Hudson) Sprengel

Uncommon at all stations. Present on rocks in low tide pools

and extending into the subtidal zone. A perennial. Tetraspores found in late summer and early fall. #4

Polysiphonia harveyi Bailey

Common at all stations. An epiphyte on various algae and Zostera in low tide pools and extending in the subtidal zone. A spring annual at stations 6 and 7, but found sporadically throughout the year at the remaining stations. Tetraspores and cystocarps found from August to December. #10

Polysiphonia lanosa (L.) Tandy

Common at stations 1-5; rare at the remaining stations. Only collected twice at station 7. A specific epiphyte on Ascophyllum nodosum; perennial. Tetraspores found from midsummer to November; spermatangia from winter to spring. #5

Polysiphonia nigrescens (Hudson) Greville

Common at all stations. Present on rocks and pier pilings in the lower intertidal and subtidal zones. A perennial species. Tetraspores produced from late spring to December; cystocarps evident in the summer. #10

Polysiphonia novae-angliae Taylor

Occassional at each station. Present on rocks and various algae in the lower intertidal and subtidal zones. A perennial species. Tetraspores found throughout the year. #5

Polysiphonia urceolata (Lightfoot ex Dillwyn) Greville
Common at station 1; less abundant at the remaining stations. Present on rocks and occassionally on other algae. A perennial species, although only found consistently at station 1. Tetraspores found during the summer. #5

Rhodomela confervoides (Hudson) Silva
Common at stations 1-5, less abundant at 6 and 7. Present on rocks and various algae in the lower intertidal and subtidal zones. A perennial species, but most luxurious during the winter. Tetraspores and cystocarps found during the summer. #5

Phaeophyceae

Ectocarpales

Ectocarpaceae:

Ectocarpus siliculosus (Dillwyn) Lyngbye
(including E. confervoides in Taylor, 1962) Common at all stations. An epiphyte on various algae such as Fucus spp., Laminaria spp., and Rhodymenia palmata. Extending from the intertidal zone into the subtidal. An annual, although it was found throughout the year at stations 6 and 7. In the Canal it was most common during the spring, while at station 1 maximum populations occurred in the summer. #14

Pilayella littoralis (L.) Kjellman
(= Pylaiella littoralis (L.) Kjellman in Taylor, 1962) Common at all stations. An epiphyte on various algae in the intertidal and upper subtidal zones. A perennial species, although it became rare during the summer at stations 6 and 7. Unilocular and plurilocular sporangia found throughout the year, except during the warmest months at stations 6 and 7. #5

Giffordia granulosa (Smith) Hamel
Uncommon, except at stations 6 and 7. Sometimes found on rocks, but more commonly as an epiphyte on various algae. Present in the intertidal and subtidal zones. A perennial (?), although it was not collected throughout the year. Maximum reproduction occurred during the colder months. #5

Giffordia secenda (Kützing) Batters

Uncommon at all stations; only collected a few times. Epiphytic on various algae in the intertidal and subtidal zones; Perennial (?). #15

Sphacelariales

Sphacelariaceae:

Sphacelaria cirrosa (Roth) C. Agardh

Common at all stations on fucoids. Occurring in the intertidal and upper subtidal zones. A perennial species. Propagules found from April to November at stations 6 and 7, and from June to November at the other stations. #4

Chordariales

Myrionemataceae:

Myrionema strangulans Greville

A common epiphyte on Ulva lactuca at all stations, especially 1-5. Occurring from the mid intertidal to the subtidal zone. Perennial (?). Unilocular sporangia found during the winter. #14

Ralfsiaceae:

Ralfsia fungiformis (Gunner) Setchell et Gardner

Relatively common at station 1, occassionally found at all other stations. Present on rocks from the mid intertidal to the subtidal zone. Perennial as documented by observations in New Hampshire (A. C. Mathieson, personal communication) and at station 1. #1

Ralfsia verrucosa (Areschoug) J. Agardh

Common at stations 1,2,6 and 7; uncommon at the remaining stations. Present on rocks in the mid-lower intertidal zone, particularly in tide pools. A perennial species. Unilocular sporangia found from July to November south of the Cape, throughout the year at Scituate, and only during the summer in the Canal. #5

Elachistacae:

Elachista fucicola (Velley) Areschoug

(= Elachistea fucicola (Velley) Areschoug in Taylor, 1962)

A common epiphyte on fucoids and other course algae at all stations. Collected from the mid to lower intertidal zones. A perennial species; however, its best vegetative development occurs during the summer. Unilocular sporangia formed from May to December. #5

Chordariaceae:

Sphaerotrichia divaricata (C. Agardh) Kylin

Only found in the subtidal zone at stations 6 and 7. An epiphyte on various algae. A summer annual. Unilocular sporangia recorded from August to November. #5

Chordaria flagelliformis (Müller) C. Agardh

Common at all stations. Present on rocks and shell and in tide pools and extending into the upper subtidal zone. An annual occurring from April to November. Unilocular sporangia recorded from April to November. #5

Corynophlaeaceae:

Leathesia difformis (L.) Areschoug

Common at stations 1,6 and 7; occassional at stations 4 and 5, uncommon at station 3, and absent at station 2. Present on rocks and epiphytic on various algae in the lower intertidal and upper subtidal zones. A spring annual at stations 3,6 and 7, but occurring later (summer) at all other stations. Unilocular sporangia were recorded from April to July at stations 6 and 7 and during August at Scituate. #8

Desmarestiales

Desmarestiaceae:

Desmarestia aculeata (L.) Lamouroux

Only collected at stations 1-5. Common on rocks and large shells in the subtidal zone. A perennial species. Unilocular sporangia found in October. #5

Desmarestia viridis (Müller) Lamouroux

Uncommon; collected at most stations, except station 2. Present on rocks in the subtidal zone. An annual species occurring from May to July at station 6 and 7 and from June to September at station 1. Its earliest occurrence was in April at station 3. #5

Dictyosiphonales

Punctariaceae:

Asperococcus echinatus (Mertens) Greville

Occassional; at all stations except station 2. Present on rocks and epiphytic on various algae in the subtidal zone.

An annual species, most abundant during the winter and disappearing in the summer at stations 6 and 7. Deep water populations were maintained throughout the year at station 1. Unilocular sporangia were recorded in the early summer. #4

Desmotrichum balticum Kützing

Uncommon. Collected twice at station 7 and once at station 3. Present on rocks and epiphytic on various algae and Zostera in the subtidal zone. An annual species. Unilocular sporangia were found in the summer. #3

Desmotrichum undulatum (J. Agardh) Reinke

Common at stations 6 and 7, collected once at station 4, and not found at the remaining stations. An epiphyte on Zostera and other algae in the subtidal zone. An annual; first appears in the spring and becomes rare by the late summer. Unilocular sporangia recorded from March to May. #9

Punctaria latifolia Greville

Uncommon; collected occassionally at station 6 and once at stations 1,3 and 5. An epiphyte on Zostera and other algae, in the intertidal and subtidal zones. A winter annual species which may persists until summer at selected stations. Unilocular sporangia found in June. #5

Punctaria plantaginea (Roth) Greville

Relatively common at stations 6 and 7; not found at any other station. Present on rocks and epiphytic on various algae in

low tide pools and within the subtidal zone. A spring annual that disappears by August. Unilocular sporangia found in the spring and early summer. #5

Dictyosiphonaceae:

Dictyosiphon foeniculaceus (Hudson) Greville

Common at stations 1,6 and 7; rare in the Canal. Present on rocks and epiphytic on various algae in the low intertidal and subtidal zones. A perennial species with most luxurious growth during the summer. #5

Scytosiphonales

Scytosiphonaceae:

Petalonia fascia (Müller) Küntze

Common at stations 1,6 and 7; uncommon in the Canal. Present on rocks and shells in tide pools and extending to the upper subtidal zone. A winter annual, but persisting throughout the year at station 1. It disappeared from station 6 and 7 during May. Plurilocular sporangia were found throughout the year at station 1, but only during the winter at the other stations. #14

Scytosiphon lomentarius (Lyngbye) Link

(= S. lomentaria spelling in Taylor, 1962) Distribution, seasonal occurrence and reproduction as P. fascia. #14

Laminariales

Chordaceae:

Chorda filum (L.) Stackhouse

Common at all stations. Present on rocks and shells in low tide pools and in the subtidal zone. An annual species occurring from May to November at stations 6 and 7; present from early summer to fall at the remaining stations. Unilocular sporangia found from summer to fall. #5

Chorda tomentosa Lyngbye

Common at all stations. Present on rocks and shells in low tide pools and in the subtidal zone. A winter annual. It disappeared in the early spring at stations 6 and 7, but remained until mid-summer at station 1. Unilocular sporangia found from early spring to June. #3

Laminariaceae:

Laminaria digitata (Hudson) Lamouroux

Common at station 1, not found at any other location. Present on rocks in the subtidal zone. A perennial species. Unilocular sporangia found from December to April. #4

Laminaria saccharina (L.) Lamouroux

(= Laminaria agardhii in Taylor, 1962; or the -,- ecotype of L. saccharina sensu Wilce, 1965)

Common at stations 1-5; only small specimens were collected at station 7. Present on rocks in the subtidal zone. A perennial species. Unilocular sporangia found from November to April. #5

Fucales

Fucaceae:

Fucus vesiculosus Linnaeus

Common at stations 1-5; only collected occassionally at 6 and 7. Present on rocks and shells in the mid to lower intertidal. A perennial species. Receptacles were evident from November to June. #8

Fucus vesiculosus V. sphaerocarpus J. Agardh

Common at stations 6 and 7; uncommon at all other stations. Present on rocks and shells from the mid intertidal to the upper subtidal zone. A perennial species. Receptacles evident from August to May. #3

Fucus vesiculosus L. var. spiralis Farlow

Uncommon at all stations and only collected a few times. Present on rocks in the mid to upper intertidal zone. A perennial species. #6

Fucus spiralis Linnaeus

Relatively common at stations 1-5. Present on rocks in the upper intertidal zone. A perennial species. Receptacles evident throughout the year. #4

Fucus distichus L. emend. Powell ssp. distichus (C. Agardh) Powell. Uncommon; only collected at station 1. Present on rocks in high intertidal pools. A perennial species. Receptacles found in the spring. #1

Fucus distichus L. emend. Powell ssp. edentatus (C. Agardh) Powell. Only found in relative abundance at station 1. Present on rocks from the mid-intertidal to the subtidal zone. A perennial species. Receptacles found throughout the year. #5

Fucus distichus L. emend. Powell ssp. evanescens (C. Agardh) Powell. Only found at stations 1-5 where it was uncommon. Present on rocks from the mid-intertidal to the upper subtidal. A perennial species, although not collected each month.

Ascophyllum nodosum (L.) Le Jolis
Common in the intertidal zones at all stations. The plants were bleached and unhealthy looking during the summer at stations 6 and 7. A perennial species. Receptacles were found from September to June. #8

Sargassaceae:

Sargassum filipendula C. Agardh
Abundant at stations 6 and 7; towards the east end of the Canal it became progressively less abundant. No specimens were found at station 1. Present on rocks in the subtidal zone. A perennial species. Receptacles were found from late summer to mid-fall. #12

Chlorophyceae

Chlorococcales

Characiaceae:

Codiolum gragarium A. Braun

Common at stations 1 and 2; not found at any other station. Present on rocks in the upper intertidal zone, mixed with various blue-green algae (e.g. Calothrix and Lyngbya spp.). An annual. #3

Codiolum petrocelidis Kuckcuk

Collected at station 1, endophytic within Petrocelis in the low intertidal and upper subtidal zones. A summer annual. #2

Ulotrichales

Ulotrichaceae:

Ulothrix flacca (Dillwyn) Thuret

Common at stations 1,2 and 7; uncommon in the Canal. Present on rocks and epiphyte on various fucoids in the upper intertidal zone. An annual, most abundant during the winter and spring. #8

Ulvaceae:

Enteromorpha intestinalis (L.) Link

Common at all stations. Present on rocks and shells throughout the intertidal zone. An annual exhibiting precocious reproduction. Hence, it was found throughout the year. #14

Enteromorpha linza (L.) J. Agardh

Uncommon; only collected at stations 1 and 7. Present on rocks in the lower intertidal zone. An annual, occurring during the spring and early summer. #14

Ulva lactuca L.

Common at all stations, except station 6. Present on rocks and shells in low tide pools and extending into the subtidal zone. An annual with precocious reproductive capacity. #12

Monostromataceae:

Monostroma grevillei (Thuret) Wittrock

Collected at all stations, except in the Canal. Present on rocks and epiphytic on larger algae in the low tide pools. A spring annual. #4

Monostroma pulchrum Farlow

Common at all stations, except in the Canal. Present on various algae in low tide pools and extending into the upper subtidal zone. A spring annual. #4

Cladophorales

Cladophoraceae:

Urospora collabens (C. Agardh) Holmes et Batters

Only collected at station 1 where it was common on rocks and shells in the mid to upper intertidal zone. Associated with Bangia spp., Calothrix spp., and Ulothrix flacca. A spring-summer annual. Zoospores found during late summer. #1

Urospora penicilliformis (Roth) Areschoug

Occassionally collected at stations 1 and 7; found once in the Canal. Present on rocks and shells in the mid to upper intertidal zone. Rare in tide pools. A winter-spring annual. Zoospores found from March to June. #4

Chaetomorpha atrovirens Taylor

Common at station 1. Not collected at the other stations. Found entangled amongst other algae, such as Chondrus and Gigartina. Present in the lower intertidal and subtidal zones. Perennial (?); with maximum abundance during the summer. #4

Chaetomorpha linum (Müller) Kützing

Common at all stations, except 4. Habitat as C. atrovirens. A perennial species. #14

Chaetomorpha melagonium (Weber et Mohr) Kützing

Common at stations 1,2,4,5; occasional at stations 3,6 and 7. Present on rocks and shells in low tide pools and extending into the subtidal zone. A perennial species. #5

Rhizoclonium tortuosum Kützing

Common at stations 1 and 2; not collected at the remaining stations. Present on rocks in low tide pools. A perennial species. #8

Cladophora flexuosa (Müller) Harvey

(= C. sericea (Hudson) Kützing sensu van den Hoek 1963) Collected at all stations except 2; most common at 5-7. Present

on rocks in low tide pools and extending into the subtidal. A perennial species (?), but most frequently collected during June. #14

Cladophora gracilis (Griffiths ex Harvey) Kützing
(= C. sericea (Hudson) Kützing sensu van den Hoek, 1963)
Common at station 7; rare at all other stations. Present on rocks in tide pools and extending into the subtidal zone. A perennial species (?). #14

Spongomorpha arcta (Dillwyn) Kützing
Common at stations 1,2,6 and 7; uncommon in the Canal. Present on rocks from the mid-intertidal to the subtidal zone. A spring annual. #5

Spongomorpha spinescens Kützing
Common at station 1; uncommon at all other stations. Present on rocks and shells from the lower intertidal to the upper subtidal zone. An annual species, occurring from April to July at Scituate. #1

Siphonales
Codium fragile (Sur.) Hariot ssp. tomentosoides (van Goor) Silva. Common at stations 3-7. Present on rocks and shells in the subtidal zone. A perennial or pseudoperennial species. Gametangia found throughout the year. #7